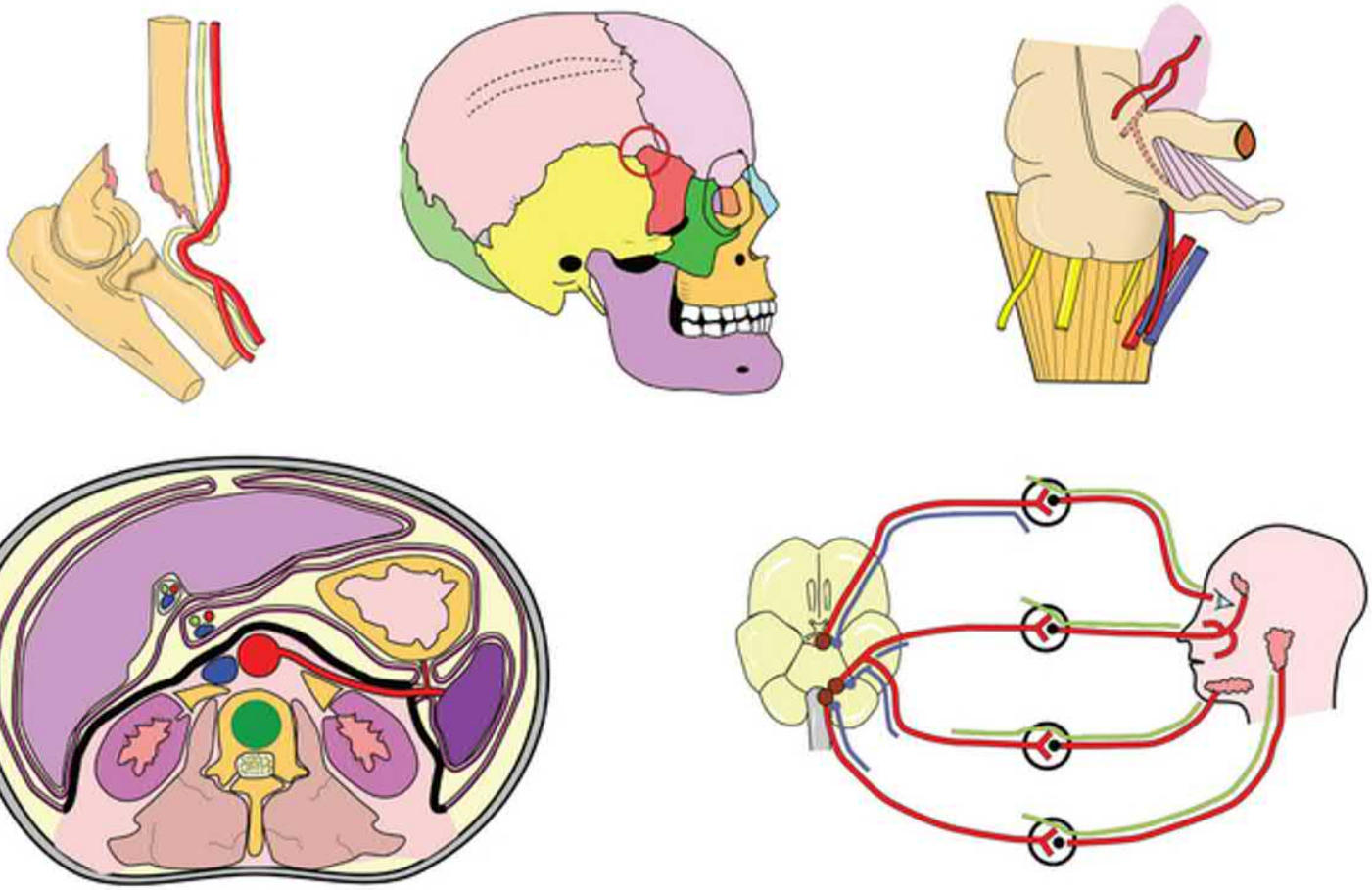
ROBERT H. WHITAKER

A VISUAL GUIDE TO CLINICAL ANATOMY



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A Visual Guide to Clinical Anatomy

A Visual Guide to Clinical Anatomy

Robert H. Whitaker, MA, MD, MCHIR, FRCS
University of Cambridge
Cambridge, UK

WILEY Blackwell

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Preface

Robert H. Whitaker

It is easier to say what this book is not, rather than what it is. It is definitely not a textbook or an atlas but simply a series of images that I have used for teaching over the last 30 years as an Anatomy Lecturer and Demonstrator in The University of Cambridge, UK. The images have also been used for numerous lectures, courses and meetings elsewhere.

Each image is designed to give a synopsis of anatomical and clinical information about an individual topic or clinical condition for both medical students and those in clinical practice. I have drawn each image myself using *Adobe Illustrator*, a graphics programme that I can recommend to all aspiring anatomical artists.

Anatomists have often been accused of teaching students too much detail that is not clinically relevant and I have been very much aware of this. I have strived only to teach anatomy that will be pertinent to their varied clinical careers and constantly endeavoured to find easy ways to learn and remember the vast amount of information that anatomy comprises.

I make no apology for a lack of neuroanatomy as it is outside my field. There is relatively little embryology amongst these images but six concise podcasts in embryology in the form of lectures with images can be found on www.instantanatomy.co.uk (a subscription website) which includes a panacea of descriptive anatomy. www.instantanatomy.net is a free, similar website with fewer lectures. I also make no apology that you will find duplication of both illustrations and text on two or more images throughout. This is intentional as often the same information is needed for any individual teaching slide.

I would be delighted if some of you wish to use the images in this book for your own lectures or teaching and you are very welcome to do so with an acknowledgement.

I am most grateful to Mr John Fergus FRCS who very kindly helped me to check every image for anatomical and clinical accuracy. I took advice from a team of experts for the sections on the heart (Professor John Wallwork, CBE, FRCS, FMedSci), the eye (Mr. Nick Sarkis, FRCS) and ear, nose and throat (Mr. Roger Gray, FRCS). To each of them I am eternally grateful.

Robert H. Whitaker
2020

Foreword

By Professor Harold Ellis

Human Anatomy is intrinsically interesting - surely everyone likes to know how he or she is constructed. However, it is, of course, of immense practical importance to people in the healing professions. Just as the London taxi driver needs to learn "the knowledge" of the streets of the metropolis, so health workers need to know what lies below their palpating fingers. Of course, surgeons need to be especially competent anatomists.

The early anatomy textbooks had no or few illustrations, and these were mostly crude and grossly inaccurate. In 1543 came a revolution; the publication by the young anatomist Andreas Vesalius, of Padua, of "*De Humani Corpora Fabrica*", (the structure of the human body). Its revolutionary contribution was not so much the text but the magnificent illustrations – good enough and often still used today. Interestingly, there is still debate about who some of these anonymous artists were.

Good teachers of Anatomy, without exception, can produce clear and accurate diagrams; those that are most appreciated are ones that the student can reproduce. Robert H. Whitaker, a retired urologist and now Anatomy teacher, is well known for his Anatomy texts and his lectures, which are illustrated by his own clearly reproducible illustrations. This new publication will prove useful to both undergraduate and graduate students in reinforcing their anatomy studies. I only wish a book like this had been available all those years ago, when I was an Anatomy student!

Professor Harold Ellis, CBE, DM, MCh, FRCS
Emeritus Professor of Surgery, University of London; Clinical Anatomist, Guy's Campus London SE1 1US, UK

Foreword

By Professor Sir Roy Calne

I have known Robert H. Whitaker for nearly 50 years as a surgical colleague, friend and fellow artist working together at Addenbrooke's Hospital in Cambridge, UK. We have shared Surgical Grand Rounds, Committee Meetings and many other hospital and social activities. We have an underlying mutual respect. With the production of this unique anatomical book he has introduced us to a new approach to teaching in that it is neither an atlas nor is it a textbook. When you delve into this beautifully illustrated book you will be impressed with its fund of knowledge and bright, colourful images.

Robert has produced some 920 annotated anatomical images that provide a concise synopsis of what is important for students and others to know and retain in order to undertake safe and competent clinical practice in any branch of medicine. These clear and beautiful images are a feat indeed!

A knowledge of anatomy is as relevant today as it was a century ago and I remember a comment I made in the Christmas Edition of the British Medical Journal many years ago when endoscopic surgery was in its infancy, that there was a risk of endoscopic surgeons not being able to get out of trouble with an open operation if they did not have an accurate working knowledge of the anatomy of the region.

Each image tells a story of a particular aspect of anatomy and its relevance to clinical practice. This brings the subject to light and its beautiful presentation makes it interesting, enjoyable and memorable.

Professor Sir Roy Calne, MA, MS, FRS, FRCS, FRCP
Emeritus Professor of Surgery, University of Cambridge and Addenbrooke's Hospital, Cambridge CB2 0QQ, UK

About the Author

Robert H. Whitaker, MA, MD, MChir, FRCS, FMAA graduated from Selwyn College, Cambridge before undertaking his clinical training at University College Hospital, London. He spent a year at Johns Hopkins Hospital, Baltimore in the Urological Research Laboratories before returning to the St Peters Hospital Group in London to train as a urologist. He was a Senior Lecturer at the London Hospital Medical School before being appointed as a Consultant Urological Surgeon at Addenbrooke's Teaching Hospital in Cambridge, UK in 1973.

He spent 20 years practising mostly paediatric urology during which time he co-founded the British Association of Paediatric Urologists. He was an examiner for the Primary FRCS and later the MRCS at all four Colleges of Surgeons in the UK and a Hunterian Professor at the Royal College of Surgeons of England in 1973. He retired in 1990 to teach anatomy in the Department of Anatomy in Cambridge for the next 30 years. He is an Honorary Fellow and Examiner for the Medical Artists' Association of Great Britain and was awarded the Farquharson Teaching Award by the Royal College of Surgeons of Edinburgh in 2013. He was awarded the St Peter's Medal of the British Association of Urological Surgeons in 1994 and was made an Honorary Member of the European Society of Paediatric Urology in 2019.

Robert H. Whitaker is author of the anatomy textbook *Instant Anatomy*, now in its fifth edition (co-authored by Neil Borley), and has anatomy teaching websites – *www.instantanatomy.net and www.instantanatomy.co.uk*

Cambridge, UK
2020

SECTION 1

Upper Limb

1.1 General Anatomy, *2*
1.2 Shoulder and Arm, *13*
1.3 Axilla, Brachial Plexus and Nerve Lesions, *31*
1.4 Elbow and Forearm, *52*
1.5 Wrist and Hand, *62*

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1.1 General Anatomy

SURFACE ANATOMY

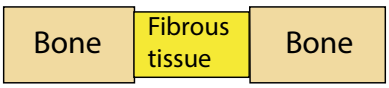
Function of any bone:

- To give form
- For muscle attachments
- Movement
- Protection of internal organs
- Metabolic
  - Calcium, phosphorus
  - Haemopoiesis

CLASSIFICATION OF JOINTS 1

FIBROUS

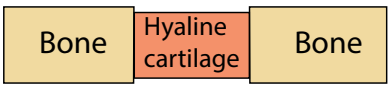
Skull sutures
Interosseous membranes
Inferior tibiofibular
11th, 12th costotransverse



CARTILAGINOUS

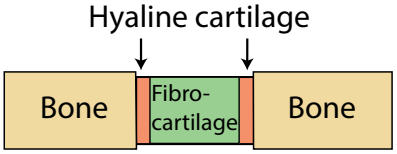
Primary

Costochondral
1st sternochondral
Spheno-occipital



Secondary

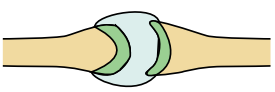
Midline symphyses
Intervertebral



SYNOVIAL

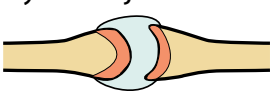
ATYPICAL SYNOVIAL

Articular surface covered with fibrocartilage
Tempormandibular
Sternoclavicular
Acromioclavicular
2-7 Sternochondral



TYPICAL SYNOVIAL

Articular surface covered with hyaline cartilage
All other synovial joints



CLASSIFICATION OF JOINTS 2

- **PLANE**
  Tarsus and carpus

Gliding

- **HINGE**
  Interphalangeal

Flexion
Extension

- **MODIFIED HINGE**
  Knee

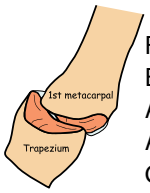
Flexion
Extension
Rotation with flexed knee

- **CONDYLOID**
  Metacarpophalangeal

Flexion
Extension
Adduction
Abduction
Circumduction

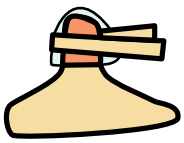
MOVEMENTS IN SYNOVIAL JOINTS

- **SADDLE CONDYLOID**
  1st Carpometacarpal

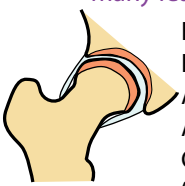


Flexion
Extension
Adduction
Abduction
Circumduction
"Controlled" rotation
= opposition

- **PIVOT**
  Both ends of radius
  Atlanto-axial
  Rotation
  (Uni-axial)

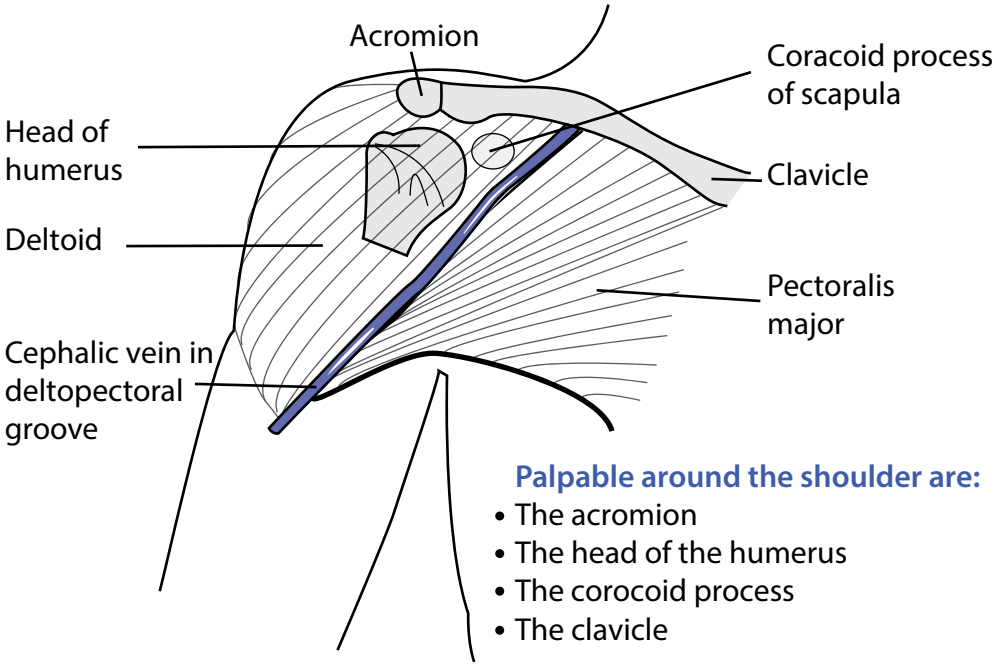


- **BALL AND SOCKET**
  Hip
  Shoulder
  (Sternoclavicular and
  Talocalcaneonavicular
  many features of one)



Flexion
Extension
Adduction
Abduction
Circumduction
"Free" rotation

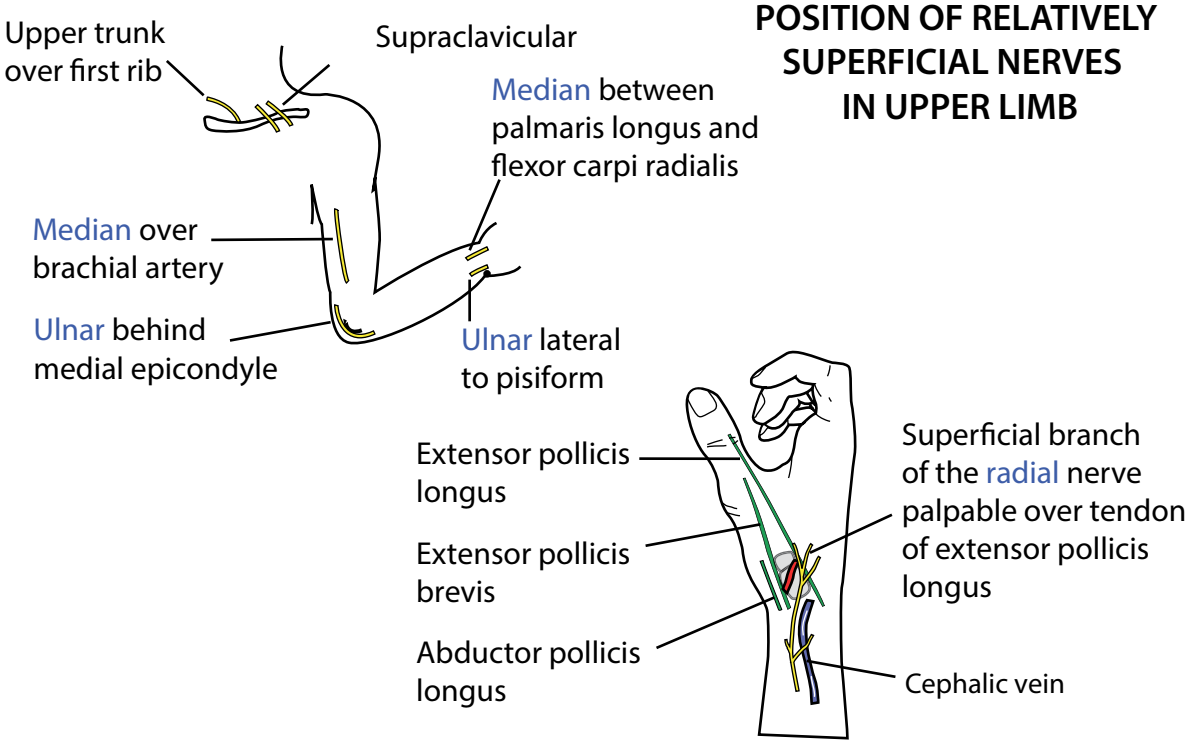
LANDMARKS AROUND SHOULDER



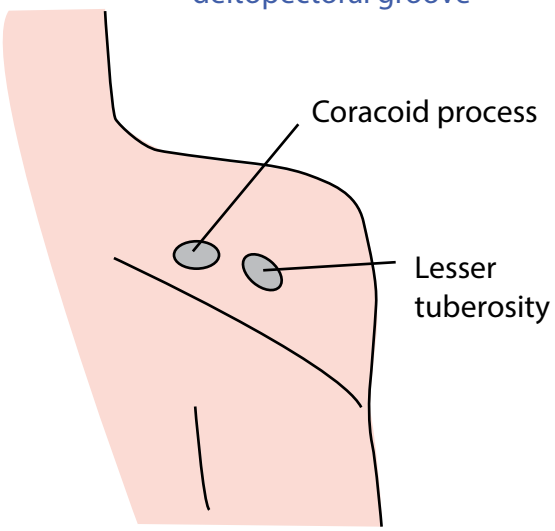
Palpable around the shoulder are:

- The acromion
- The head of the humerus
- The corocoid process
- The clavicle

POSITION OF RELATIVELY SUPERFICIAL NERVES IN UPPER LIMB

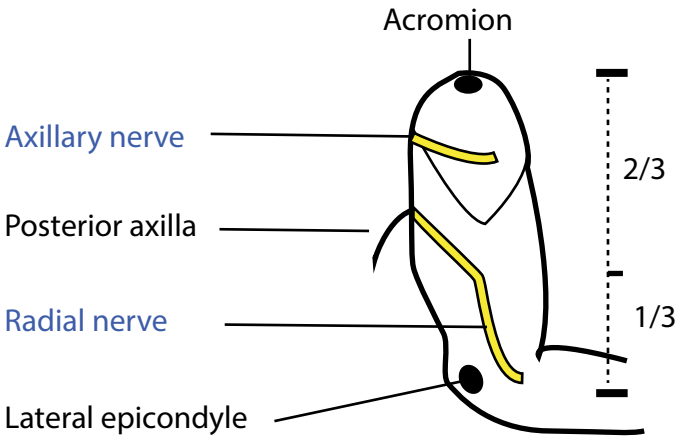


PALPABLE STRUCTURES IN THE UPPER LIMB



- Acromioclavicular joint
- Medial and lateral epicondyles
- Olecranon
- Head of radius
- Anconeus (posterior to olecranon)
- Radial and ulnar styloid processes
- Dorsal (Lister's) tubercle of radius
- Hook of hamate
- Biceps tendon and aponeurosis
- Brachial, radial and ulnar pulses

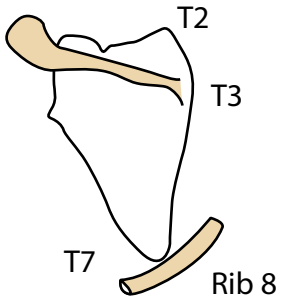
VULNERABLE NERVES IN THE ARM



RADIAL NERVE

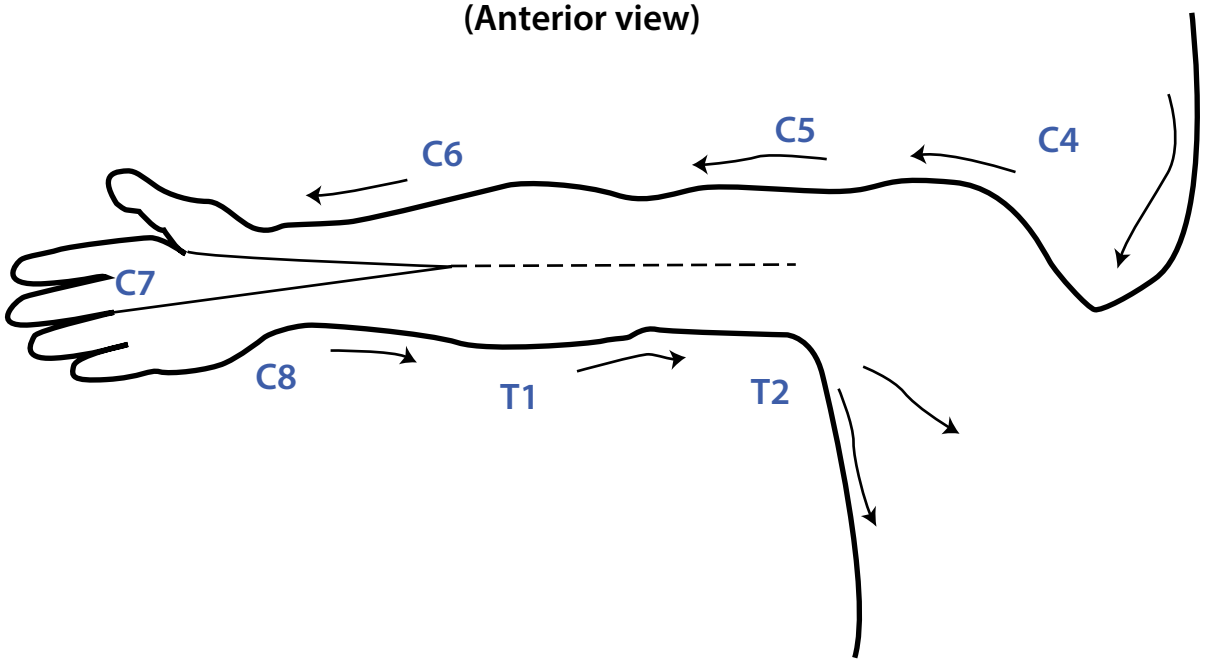
Passes from where the posterior axilla meets the arm to a point 2/3 down a line from acromion to the lateral epicondyle then it passes anterior to the lateral epicondyle

LEFT SCAPULA

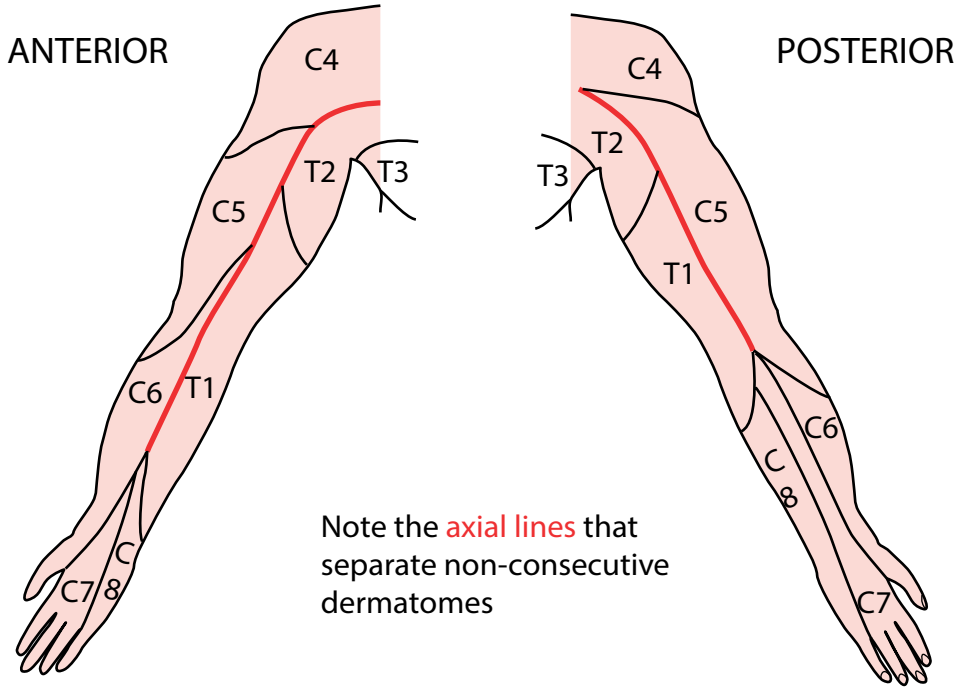


- Covers half the ribs 2-7
- 8th rib is first below
- Upper border at T2
- Medial spine at T3
- Lower border at T7

DERMATOMES IN THE OUTSTRETCHED UPPER LIMB
(Anterior view)

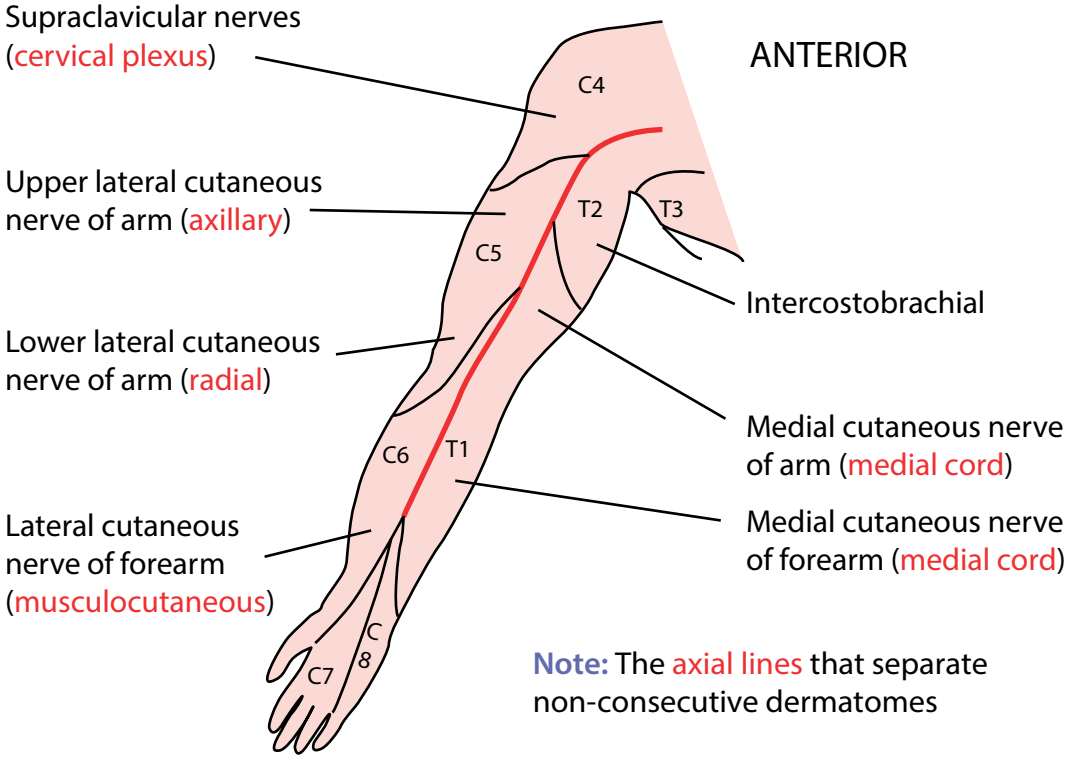


UPPER LIMB DERMATOMES

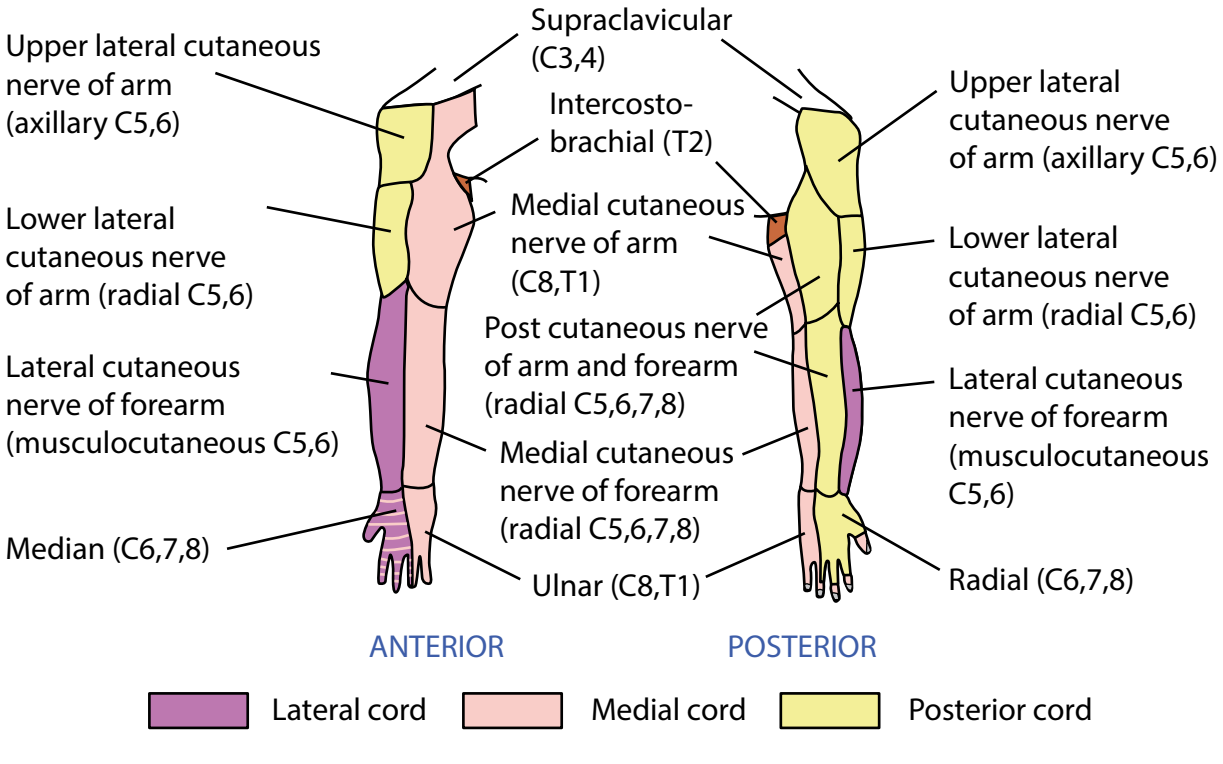


Note the axial lines that separate non-consecutive dermatomes

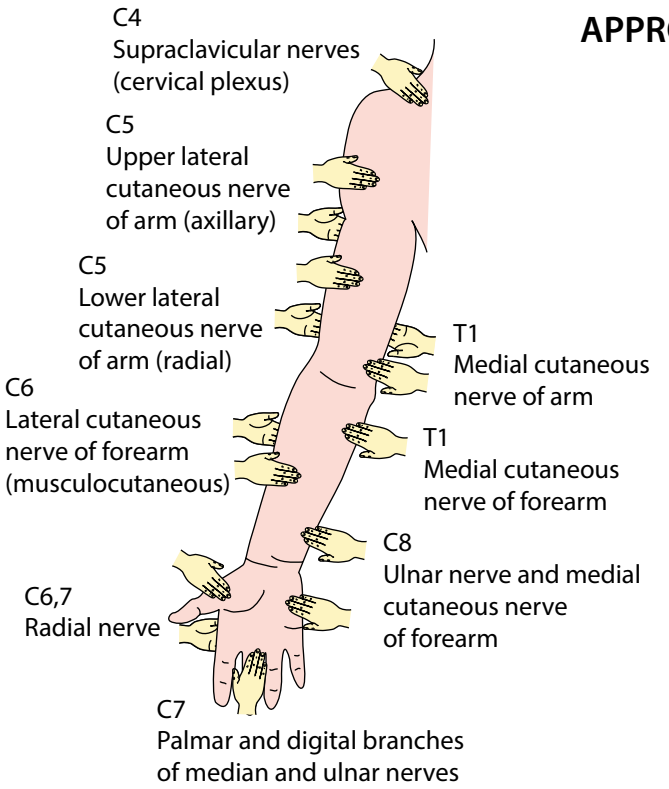
UPPER LIMB DERMATOMES



CUTANEOUS NERVES OF THE UPPER LIMB



APPROXIMATE DERMATOMES OF UPPER LIMB

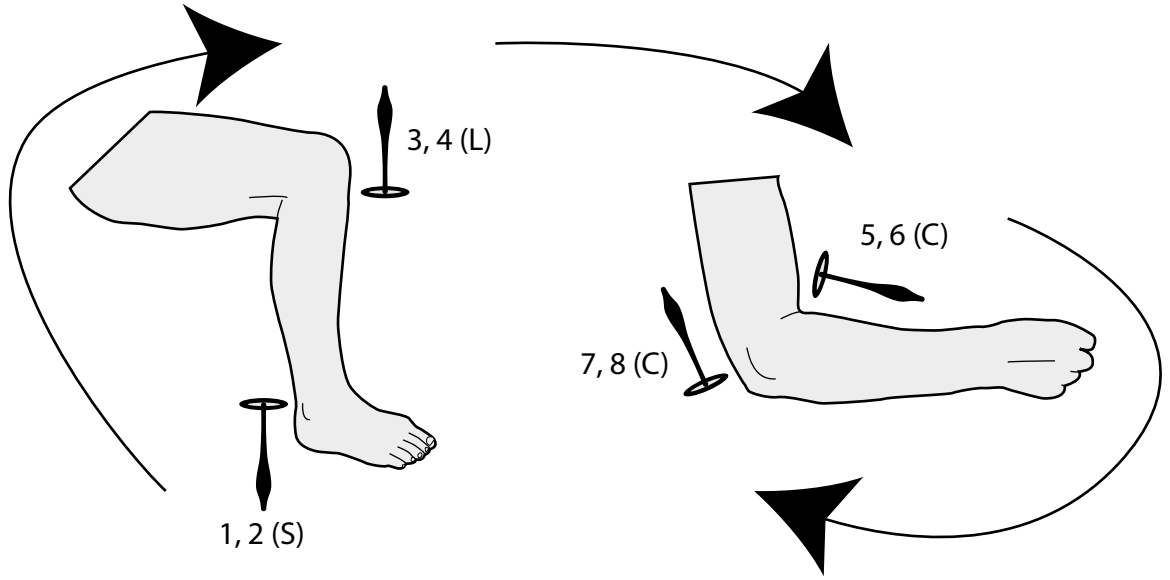


Above the elbow the anterior dermatomes reach round posteriorly to meet an axial line. Supply posteriorly is by the posterior cutaneous nerve of arm. Below the elbow supply is by the posterior cutaneous nerve of forearm (C6,7)

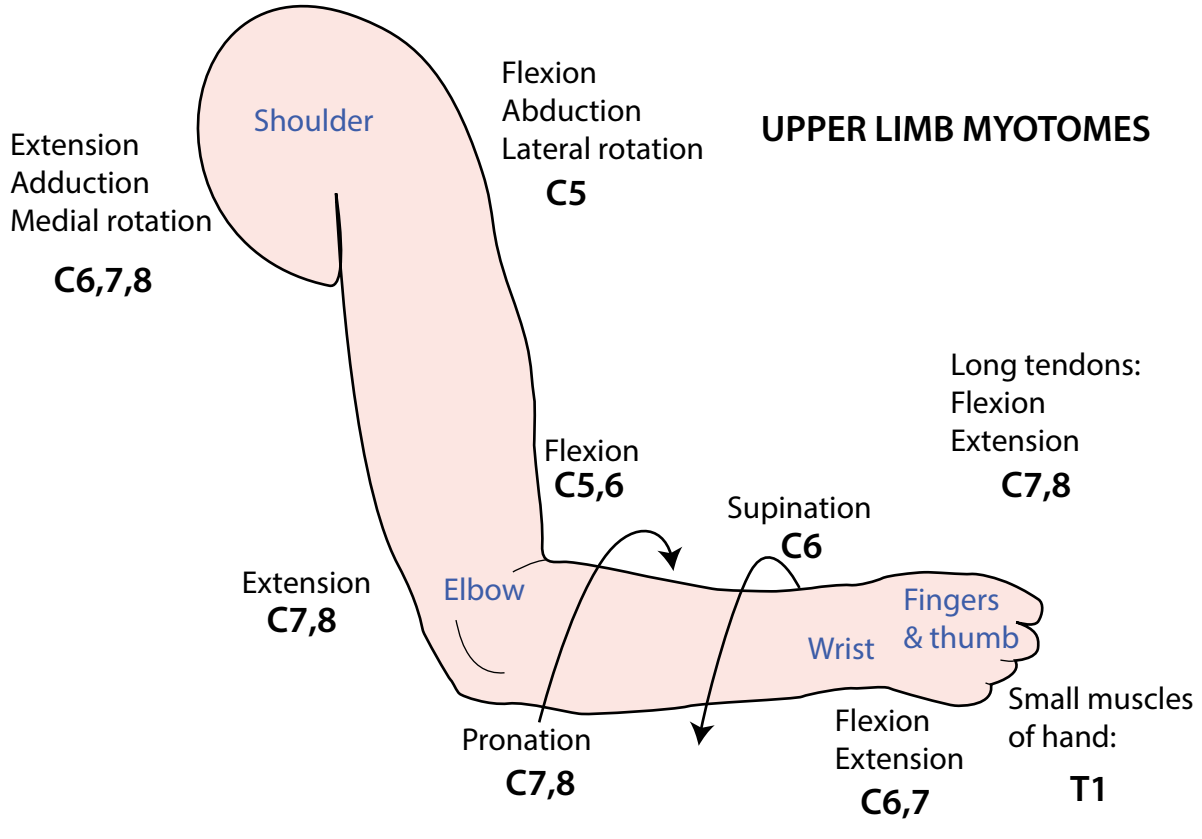
SEGMENTAL NERVE SUPPLY IN UPPER LIMB

SHOULDER:	
Flexion/abduction/lateral rotation	C5
Extension/adduction/medial rotation	C6,7,8
ELBOW:	
Flexion (biceps reflex)	C5,6
Extension (triceps reflex)	C6,7,8
FOREARM:	
Pronation	C7,8
Supination	C6
WRIST:	
Flexion/extension	C7,8
FINGERS/THUMB (LONG TENDONS):	
Flexion/extension	C7,8
HAND (SMALL MUSCLES):	
All movements	T1

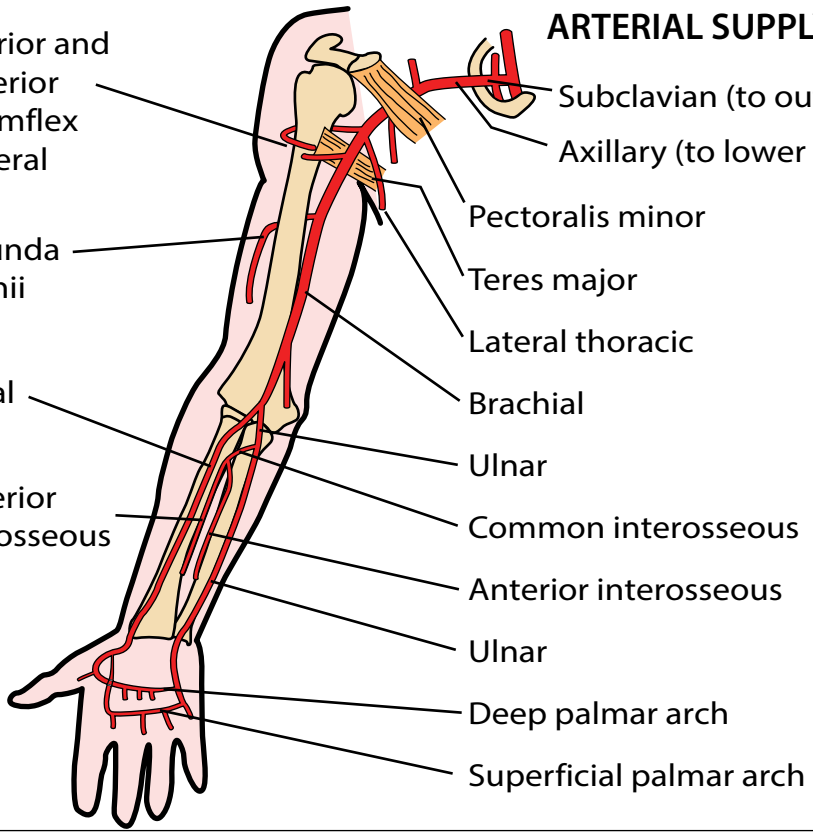
LIMB TENDON REFLEXES



UPPER LIMB MYOTOMES



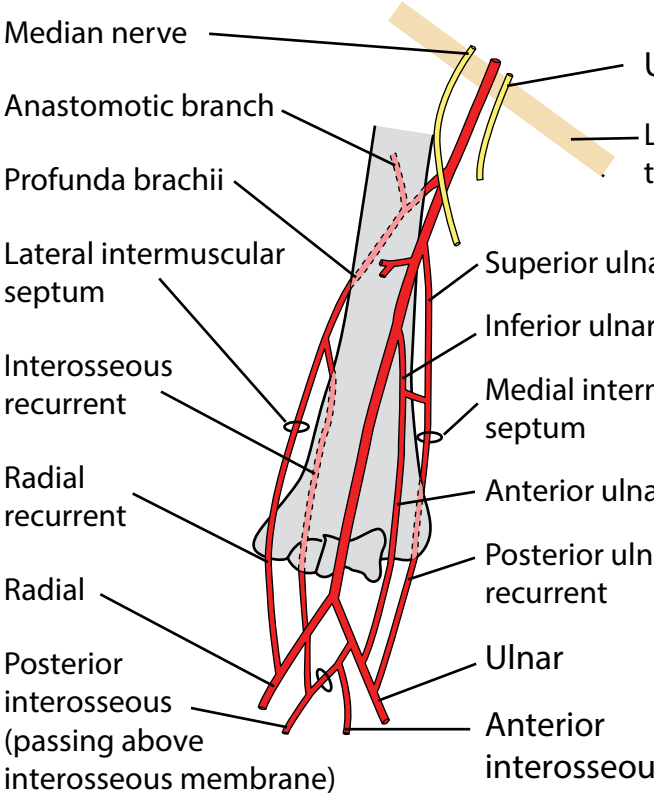
ARTERIAL SUPPLY OF UPPER LIMB

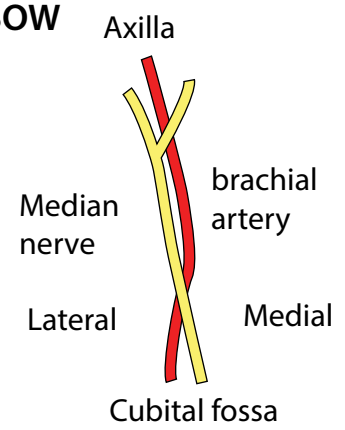


Other branches:
Muscular
Nutrient
Ulnar collateral

All arteries accompanied by venae commitantes

ARTERIAL ANASTOMOSIS AROUND RIGHT ELBOW

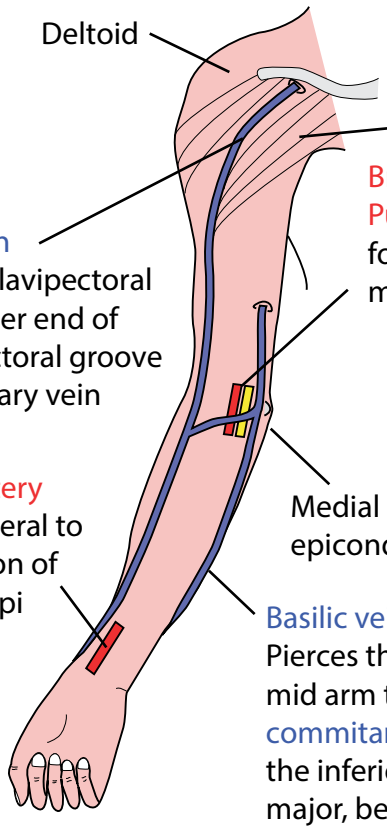




Usual arrangment but in 15% the nerve passes behind artery

Mnemonic for anastomotic vessels:
Pus - Profunda
Spells - Superior ulnar collateral
Nasty - Nutrient
Infection - Inferior ulnar collateral

SUPERFICIAL VEINS AND PULSES IN UPPER LIMB



Deltoid

Pectoralis major

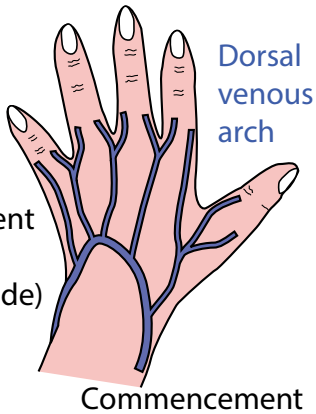
Brachial artery
Pulse. In the cubital fossa, lateral to the median nerve

Cephalic vein
Pierces the clavipectoral fascia at upper end of the deltopectoral groove to enter axillary vein

Radial artery
Pulse. Lateral to the tendon of flexor carpi radialis

Medial epicondyle

Basilic vein
Pierces the fascia in the medial mid arm to join the venae commitantes which together, at the inferior border of teres major, become the axillary vein

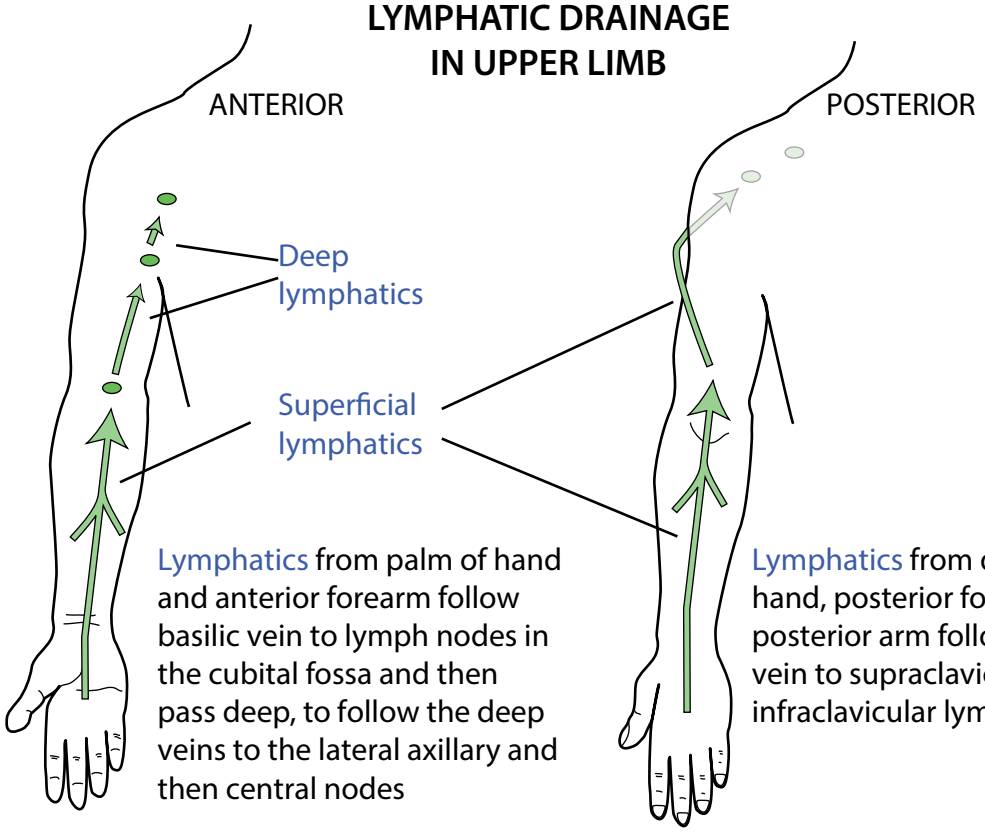


Dorsal venous arch

Commencement of the basilic vein (medial side)

Commencement of the cephalic vein (lateral side)

LYMPHATIC DRAINAGE IN UPPER LIMB



ANTERIOR

POSTERIOR

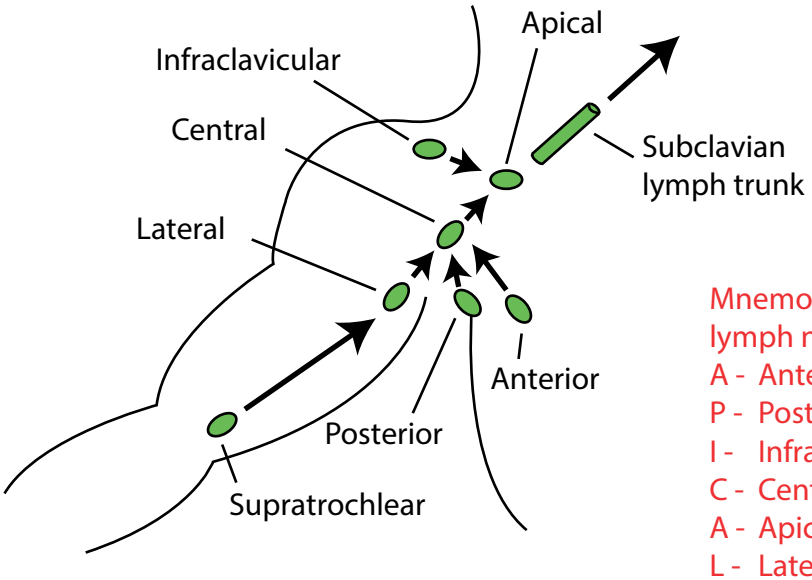
Deep lymphatics

Superficial lymphatics

Lymphatics from palm of hand and anterior forearm follow basilic vein to lymph nodes in the cubital fossa and then pass deep, to follow the deep veins to the lateral axillary and then central nodes

Lymphatics from dorsum of hand, posterior forearm and posterior arm follow cephalic vein to supraclavicular or infraclavicular lymph nodes

AXILLARY LYMPH NODES

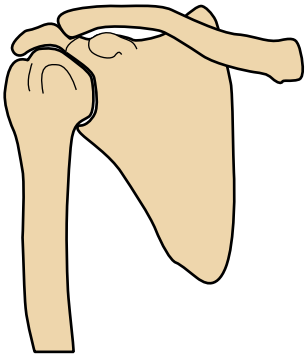


Mnemonic for axillary lymph nodes:
A - Anterior
P - Posterior
I - Infraclavicular
C - Central
A - Apical
L - Lateral

75% of lymphatics from the breast drain to axillary nodes. Others to internal thoracic, abdominal nodes or to other breast

1.2 Shoulder and Arm

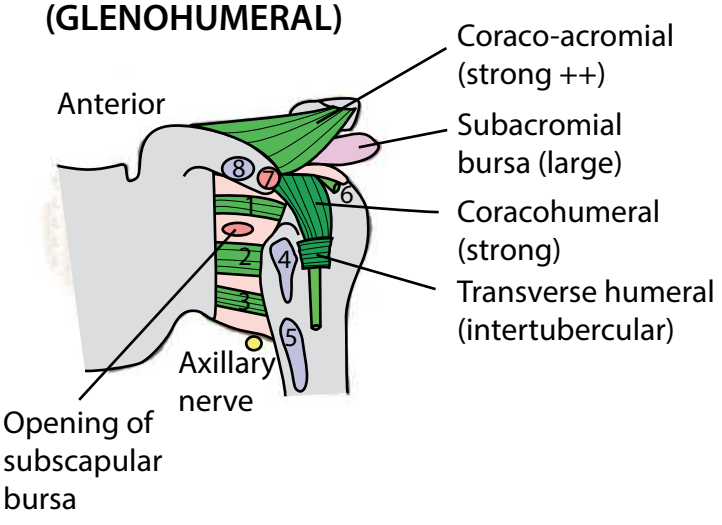
SHOULDER JOINT (GLENOHUMERAL)



Blood: Circumflex humeral arteries
Nerves: Subscapular, suprascapular, axillary (Hilton's law)
Bursae: Subscapular, subacromial, infraspinatus, supraspinatus
Stability: Bones (poor), Capsule (relatively poor), Muscles +++, ligaments +++
Support: Rotator cuff (subscapularis, supraspinatus, infraspinatus, teres minor), long head biceps, triceps in abduction, muscles from chest to arm

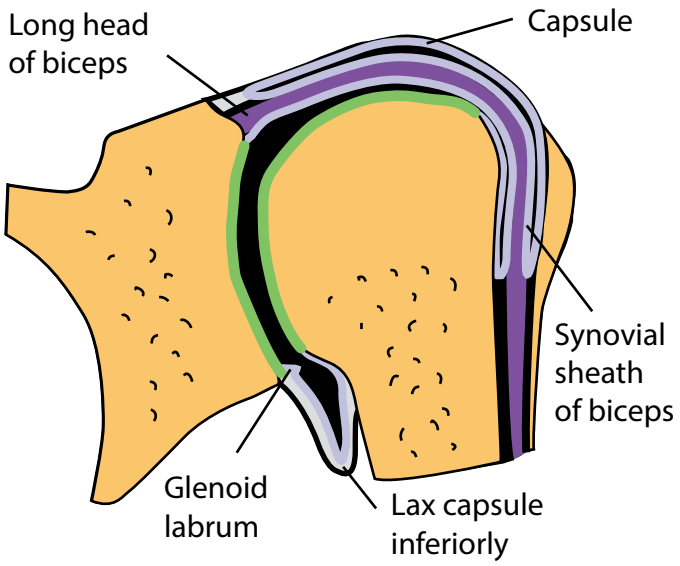
SHOULDER JOINT (GLENOHUMERAL)

LIGAMENTS:
1,2,3: Glenohumeral
Anterior: superior, middle, inferior (weak thickenings of capsule)
4: Subscapularis
5: Teres major
6: Supraspinatus
7: Short head biceps
8: Pectoralis minor



Shallow glenoid fossa - deepened by glenoid labrum. Synovial, Ball and socket. Humeral head is 1/3 hemisphere
Capsule: Strong and taut superiorly (anti-sag), inferiorly lax and inserted lower to allow wide abduction, flexion and extension. Synovium: Envelops biceps tendon, communicates with bursae anteriorly and posteriorly

SHOULDER JOINT AND ROTATOR CUFF MUSCLES



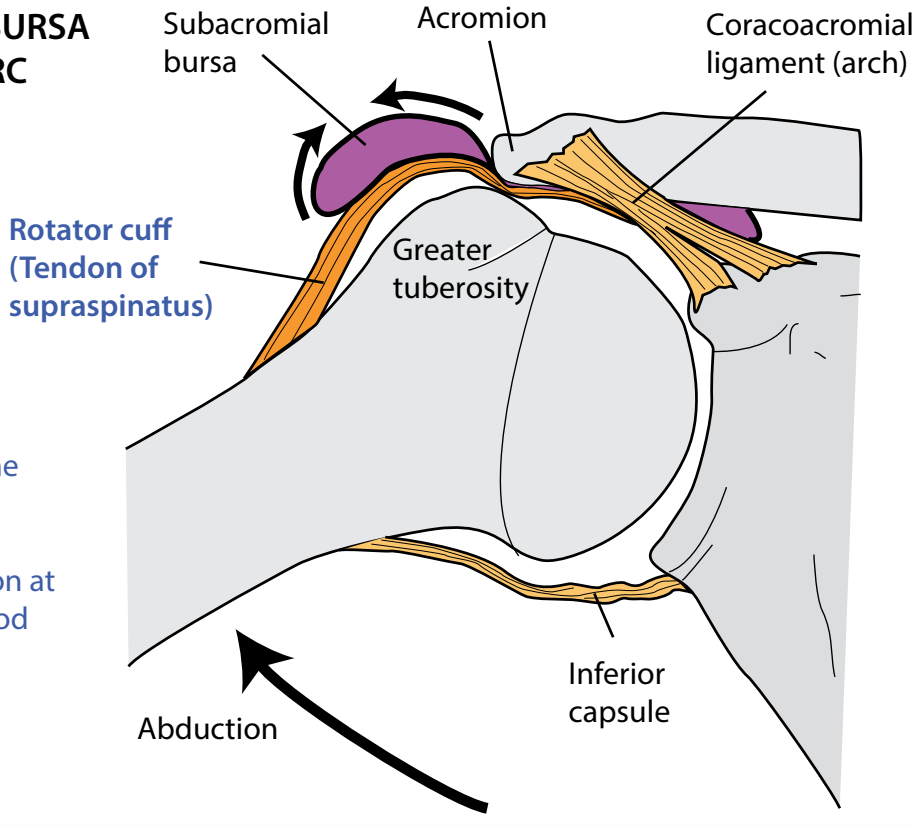
Rotator Cuff Muscles:
Subscapularis (anterior)
Infraspinatus (posterior)
Teres minor (posterior)
Supraspinatus (superior)

All blend with capsule of shoulder joint

Lax capsule inferiorly allows dislocation of head of humerus inferiorly and usually anteriorly

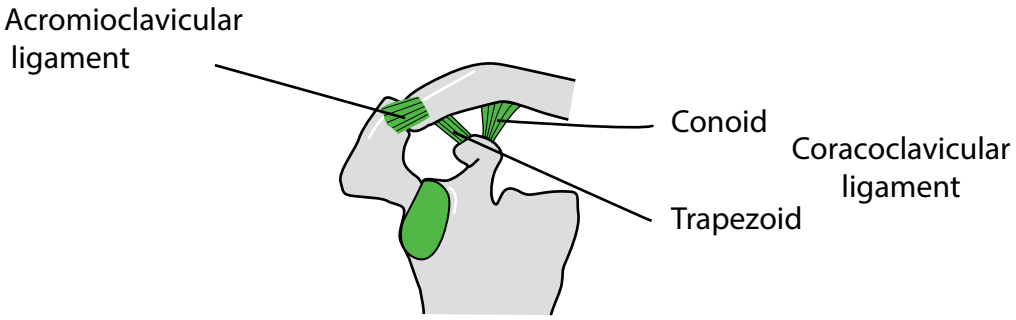
The tendon of the long head of biceps lies within the capsule but not within the synovial membrane. It attaches to the supraglenoid tubercle

SUBACROMIAL BURSA AND PAINFUL ARC SYNDROME



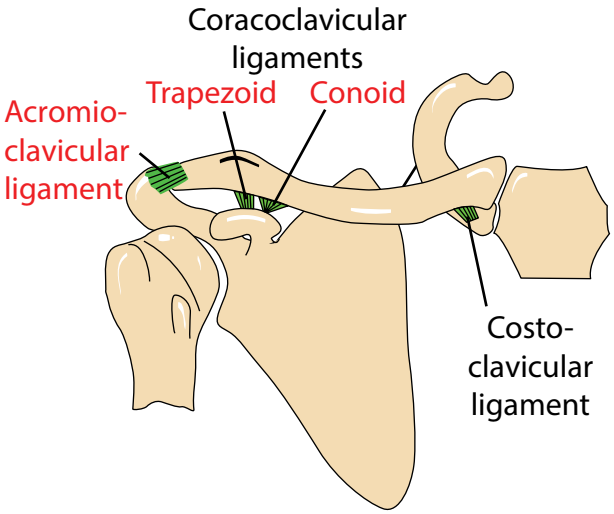
During abduction the greater tuberosity impinges on the supraspinatus tendon at its point of least blood supply beneath the acromion

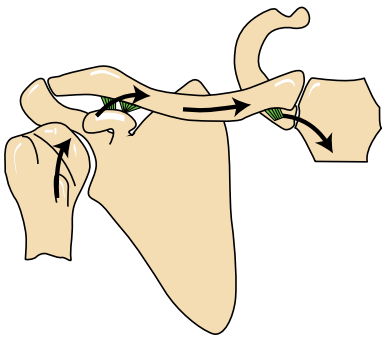
ACROMIOCLAVICULAR JOINT



- Synovial
- Atypical
- Thick superior capsule (acromioclavicular ligament)
- Incomplete fibrocartilaginous disc in upper joint
- Strong coracoclavicular ligament
- **Nerve:** Lateral supraclavicular (C4)
- **Movements:** Gliding (passive) and 20° of rotation of scapula

ACROMIOCLAVICULAR JOINT AND CORACOCLAVICULAR LIGAMENTS



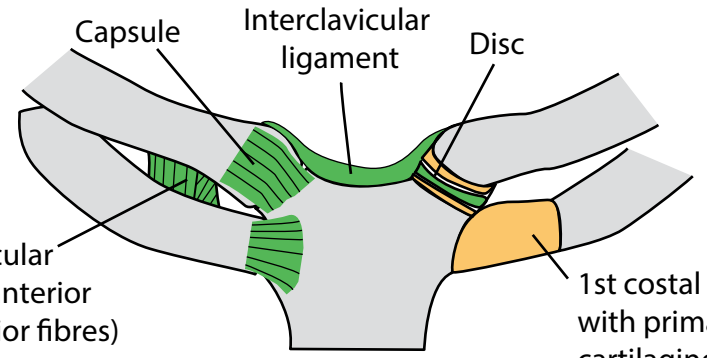


The acromioclavicular joint can dislocate but forces usually pass through coracoclavicular ligament to the clavicle then via the costoclavicular ligament to the manubrium and sternum. Excessive force will fracture the clavicle

ACROMIOCLAVICULAR JOINT

- Synovial, Atypical, Plane (passive gliding)
- Thick superior capsule (acromioclavicular ligament)
- Incomplete fibrocartilaginous disc in upper joint
- Strong coracoclavicular ligament
- Nerve: Lateral supraclavicular (C4)
- Movements: gliding (passive) and 20^{O} of rotation of scapula

STERNOCLAVICULAR JOINT

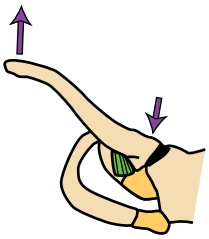


- Synovial
- Atypical (fibrocartilage on joint surfaces)
- Fibrocartilaginous disc dividing it into 2 cavities
- Manubrial surface is concave
- All the features of a ball and socket joint
- Disc attached to capsule, acts as shock absorber
- Capsule thick above and posteriorly
- Fulcrum at costoclavicular ligament
- Clavicle rotates 40 degrees
- Nerves: supraclavicular (C3,4)

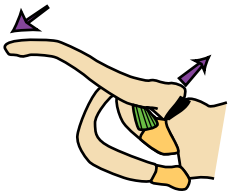
Ligaments:

- Thickening of capsule (above and posteriorly) = anterior and posterior sternoclavicular ligaments
- Interclavicular
- Costoclavicular (strong)

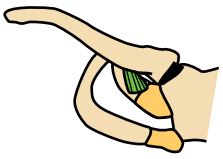
MOVEMENTS AT THE STERNOCLAVICULAR JOINT



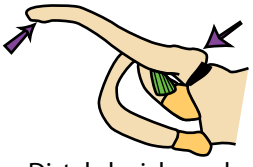
Clavicle elevated
At distal end,
medial end depresses



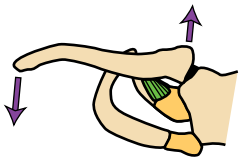
Distal clavicle is pushed forwards, medial end retracts



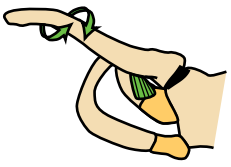
At rest



Distal clavicle pushed posteriorly, medial end protrudes



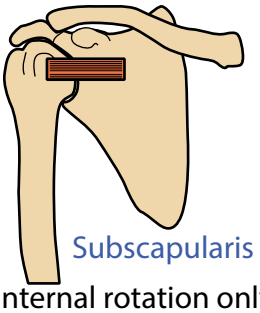
Clavicle depressed at distal end, medial end elevates



Distal and medial clavicle can rotate together

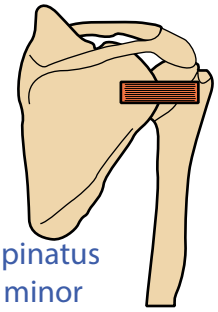
In view of all the movements described here and the ability to pivot on the costoclavicular ligament, the sternoclavicular joint can be regarded has having many the features of a ball and socket joint

PRINCIPLES OF MOVEMENTS AT JOINTS - SHOULDER



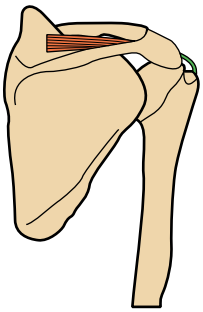
Subscapularis

- Internal rotation only
- Crosses anteriorly at level of joint



Infraspinatus
Teres minor

- External rotation only
- Crosses posteriorly at level of joint

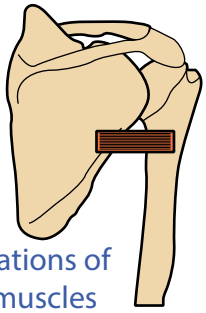


Supraspinatus
Deltoid

- Abduction only
- Crosses superorly at level of joint

Teres major
Latissimus dorsi
Pectoralis major

- Internal rotation and adduction
- Crosses both anteriorly and inferior to level of joint

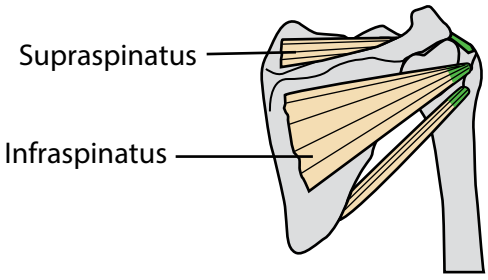


Combinations of several muscles

- External rotation and adduction
- Crosses both posteriorly and inferior to level of joint

SUPRASPINATUS

Origin: 3/4 supraspinous fossa and upper spine of scapula
Insertion: Superior facet of greater tuberosity of humerus and joint capsule
Action: Abducts and stabilises shoulder
Nerve supply: Suprascapular (C5,6 upper trunk)

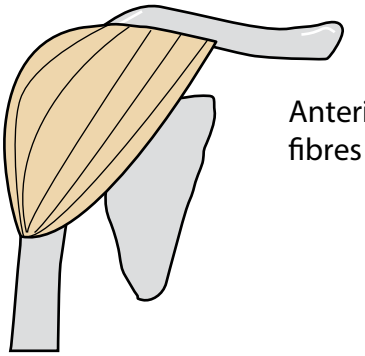


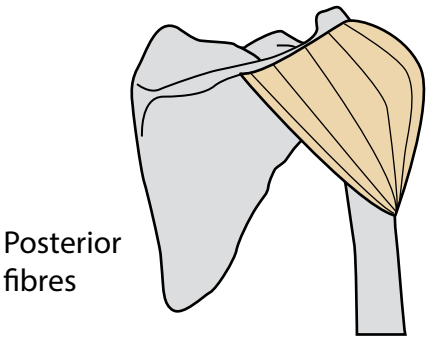
INFRASPINATUS

Origin: Medial 3/4 infraspinous fossa and intermuscular septum
Insertion: Medial facet of greater tuberosity of humerus and joint capsule
Action: Lateral rotation and stabilisation of shoulder
Nerve supply: Suprascapular (C5,6 upper trunk)

DELTOID

Origin: Lateral third clavicle, acromion, spine of scapula as far as deltoid tubercle of scapula
Insertion: Deltoid tubercle of humerus
Action: Abducts arm. Anterior fibres flex and medially rotate. Posterior fibres extend and laterally rotate
Nerve supply: Axillary (C5,6 posterior cord)





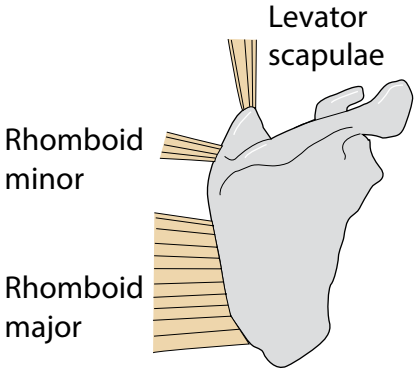
Special note: There is little doubt that the lateral fibres of deltoid help supraspinatus to initiate abduction of the shoulder but from the images above it is obvious that the anterior and posterior fibres cross the joint more effectively as soon as abduction begins and thus give more power to abduction

RHOMBOID MAJOR

Origin: Spines of T2-5 and supraspinous ligaments
Insertion: Lower half posterior medial scapula
Action: Retracts and rotates scapula to rest position
Nerve supply: Dorsal scapular (C5 from root)

RHOMBOID MINOR

Origin: Spines C7 and T1 and lower ligamentum nuchae
Insertion: Posteromedial scapula level with spine
Action: Retracts and rotates scapula to rest
Nerve supply: Dorsal scapular (C5 from root)

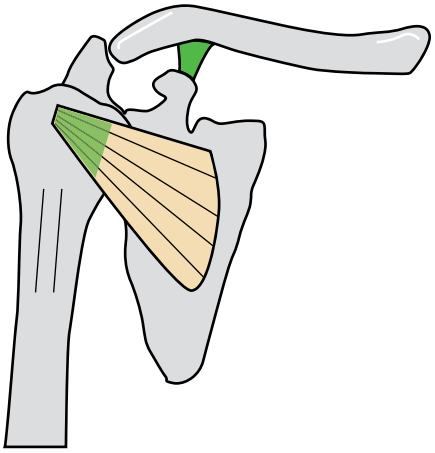


LEVATOR SCAPULAE

Origin: Posterior tubercles of transverse processes C1-4
Insertion: Upper medial border of scapula
Action: Raises medial end of scapula
Nerve supply: Dorsal scapular (C5 root)

SUBSCAPULARIS

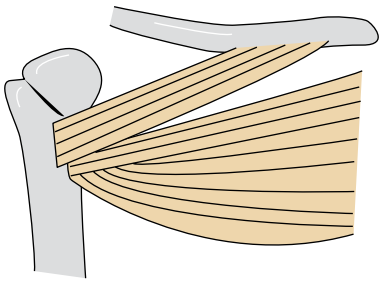
Origin: Medial 2/3 subscapular fossa
Insertion: Lesser tuberosity of humerus, half medial lip of bicipital groove, shoulder joint capsule
Action: Medial rotation stabilisation of shoulder
Nerve supply: Upper and lower subscapular (posterior cord C6,7)

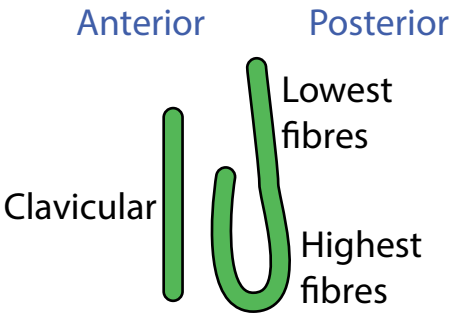


PECTORALIS MAJOR

Clavicular head
Origin: Medial half of clavicle
Insertion: Anterior lamina (of trilaminar insertion) and lateral lip of bicipital groove, deep fascia, anterior lip of deltoid tuberosity

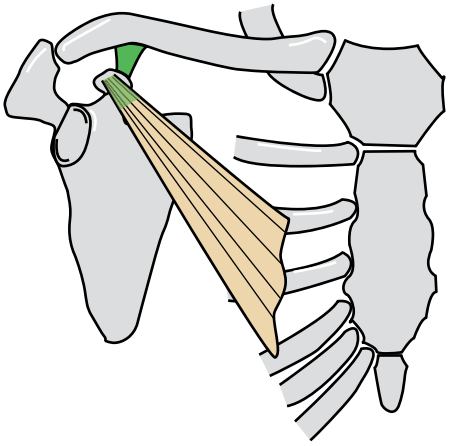
Sternocostal head
Origin: Anterior and lateral manubrium, body of sternum, aponeurosis of external oblique, upper 7 costal cartilages (not always 1st or 7th)
Insertion: Manubrial fibres to intermediate lamina. Sternocostal fibres to posterior lamina with highest fibres into capsule of shoulder
Action: Flexion, adduction, internal rotation
Nerve supply: lateral and medial pectoral nerves





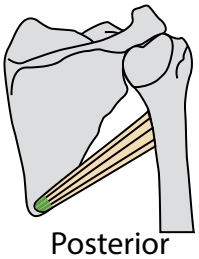
PECTORALIS MINOR

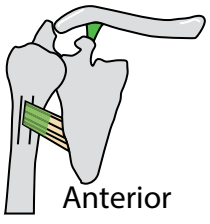
Origin: Ribs 3,4,5
Insertion: Coracoid process
Action: Protracts scapula with serratus anterior
Nerve supply: Medial and lateral pectoral nerves



TERES MAJOR

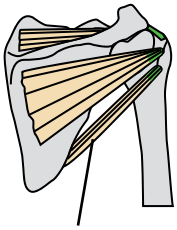
Origin: Oval area on lower third lateral side of inferior angle of scapula
Insertion: Medial lip of bicipital groove
Action: Medial rotation, adduction, stabilisation of shoulder
Nerve supply: Lower subscapular (posterior cord C5,6)


Posterior


Anterior

TERES MINOR

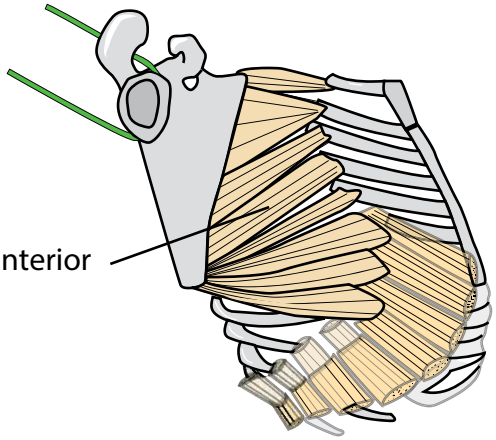
Origin: Middle third lateral border of scapula
Insertion: Inferior facet of greater tuberosity and joint capsule
Action: Lateral rotation and stabilisation of shoulder
Nerve supply: Axillary nerve (C5,6 (posterior cord)



SERRATUS ANTERIOR

Origin: Upper 8 ribs and intercostal membranes
Insertion: Inner, medial border of scapula
Action: Protracts and laterally rotates scapula
Nerve supply: Long thoracic nerve of Bell
C5 to slips 1 and 2
C6 to slips 3 and 4
C7 to slips 5, 6, 7, and 8

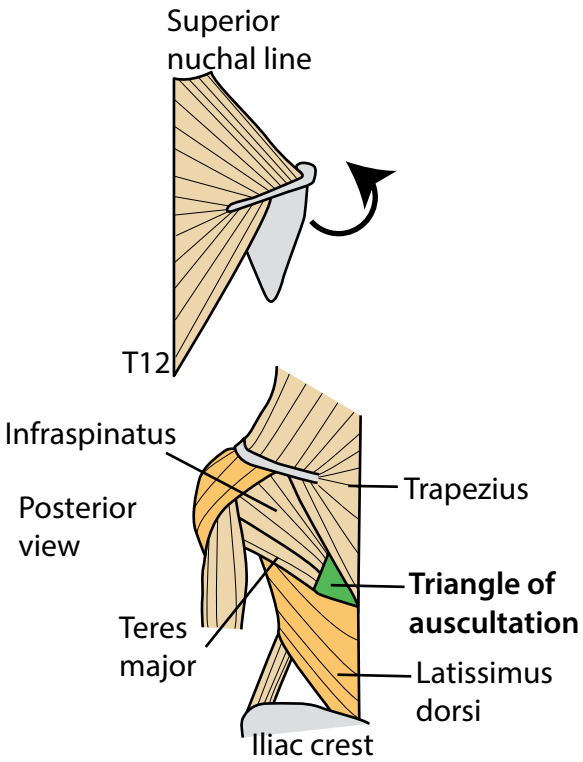
1st slip visible in posterior triangle of neck



Note: If slips 5, 6, 7, 8, under the control of C7 act alone, the scapula is rotated with minimal protraction as in abduction of the upper limb.

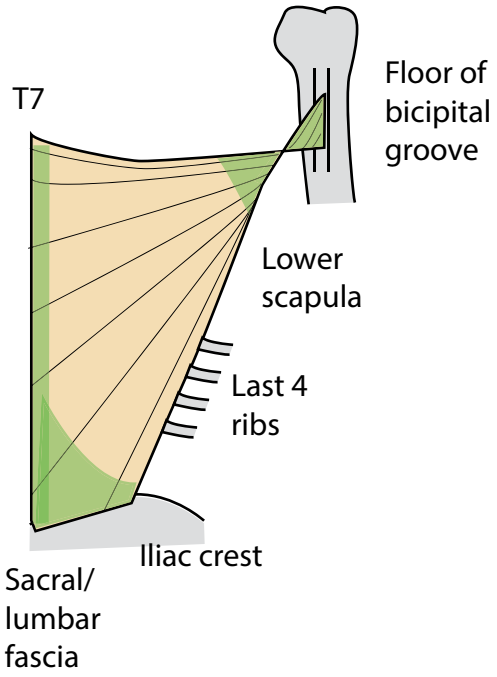
TRAPEZIUS

Origin: Superior nuchal line and crest, occiput, nuchal ligament, spines and supraspinous ligaments T1-12.
Insertion: Lateral 1/3 clavicle, medial acromion, spine of scapula around to deltoid tubercle.
Action: Lateral rotation, elevation, depression and retraction of scapula (lowest fibres elevate body when arm is fixed. Upper fibres extend and laterally flex head and neck. Rotation is aided by serratus anterior).
Nerve supply: Spinal root of accessory nerve (XI).

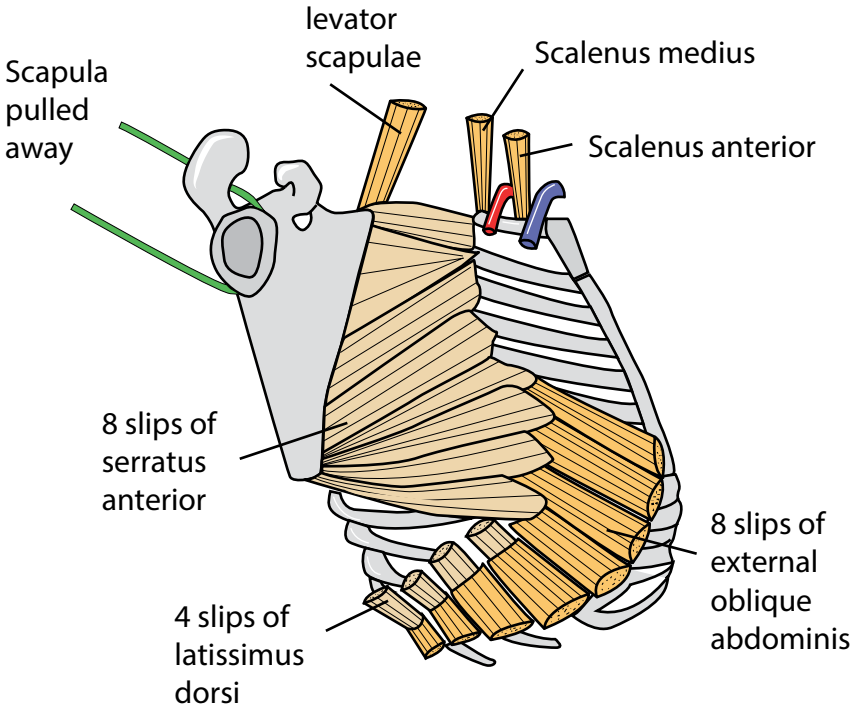


LATISSIMUS DORSI

Origin: Spines and supraspinous ligament T7 down to sacrum, lumbar fascia, posterior third of iliac crest, last 4 ribs and inferior angle of scapula.
Insertion: Flat tendon into floor of bicipital groove.
Action: Adducts, extends and medially rotates shoulder. Aids both inspiration and expiration.
Nerve supply: Thoracodorsal nerve from posterior cord.



MUSCLES ATTACHED TO RIBS



LOOKING DOWN ON RIGHT SHOULDER

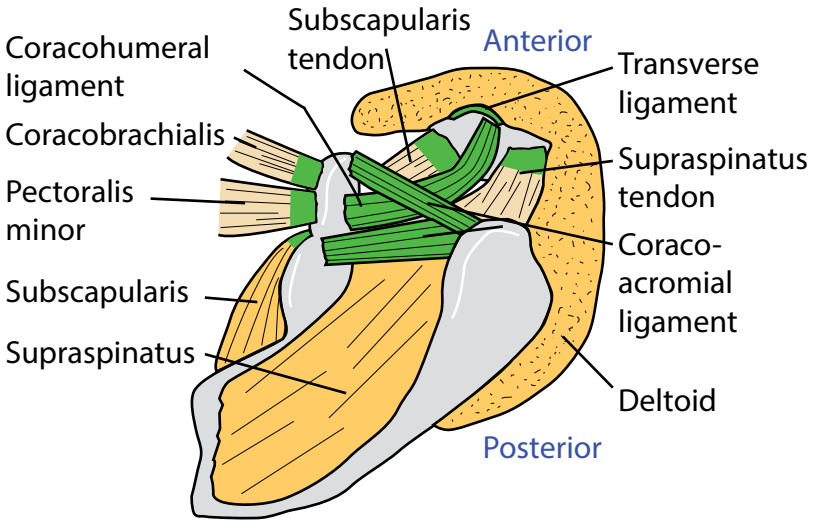
Relations

Superior: Supraspinatus, bursa, long head of biceps, coraco-acromial ligament

Inferior: Long head of triceps, axillary nerve, posterior circumflex humeral artery, teres major

Posterior: Infraspinatus, teres minor, deltoid

Anterior: Subscapularis, bursa, deltoid



Movements

Flexion: Pectoralis major, biceps, coracobrachialis, deltoid

Extension: Deltoid, latissimus dorsi, teres major

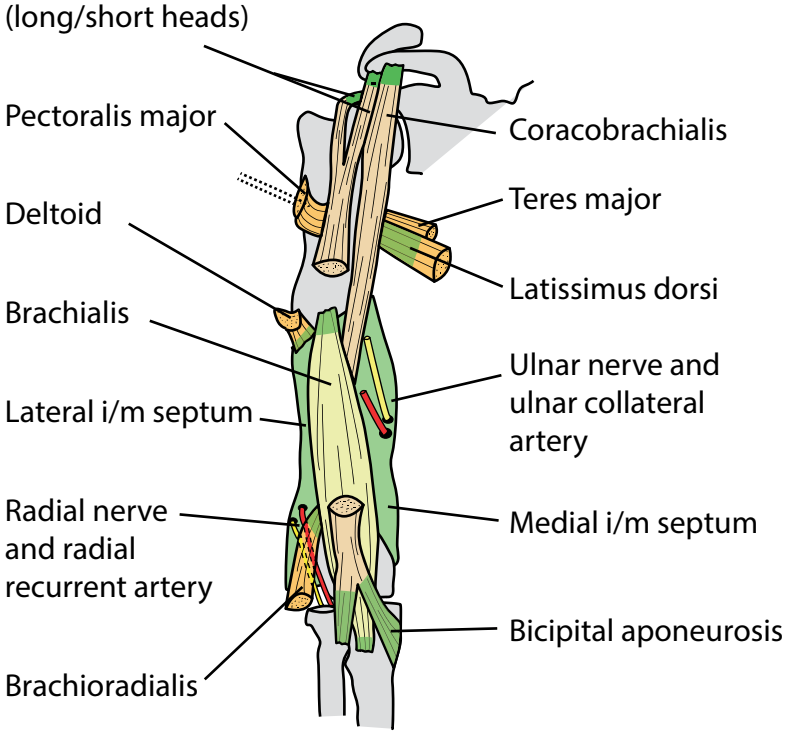
Adduction: Pectoralis major, latissimus dorsi, teres major

Abduction: Supraspinatus, deltoid

Internal rotation: Subscapularis, teres major, latissimus dorsi

External rotation: Teres minor, infraspinatus, deltoid

ANTERIOR ARM



Medial intermuscular septum (i/m)

Pierced by:
Ulnar nerve
Ulnar collateral artery

Gives origin to:
Brachialis (anteriorly)
Triceps (posteriorly)

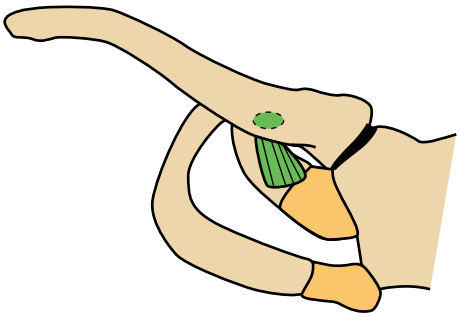
Lateral intermuscular septum (i/m)

Pierced by:
Radial nerve
Radial recurrent artery

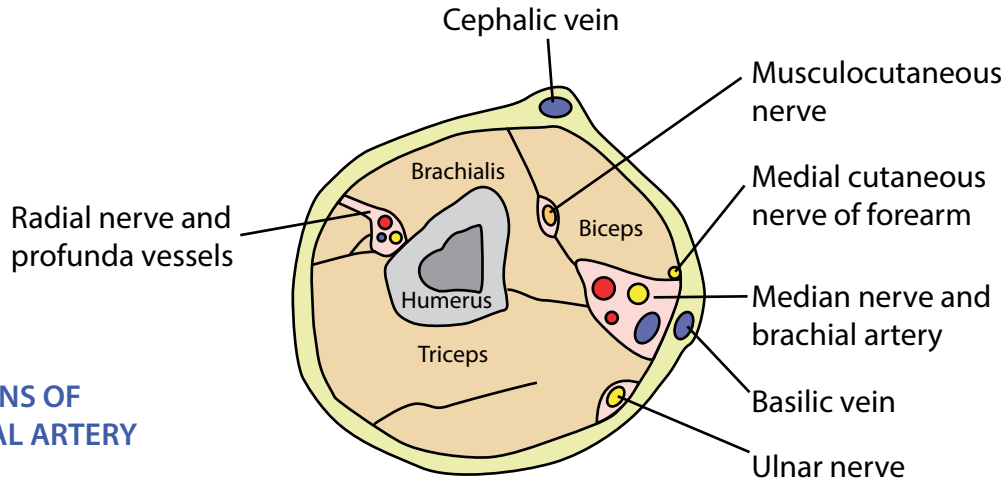
Gives origin to:
Brachioradialis (anteriorly)
Extensor carpi radialis longus (anteriorly)
Triceps (posteriorly)

SUBCLAVIUS

Origin: 1st rib, costochondral junction
Insertion: Subclavian groove inferior middle clavicle
Action: Stabilises clavicle
Nerve supply: Nerve to subclavius (C5,6 off roots)



AXIAL (CROSS) SECTION OF MID RIGHT ARM

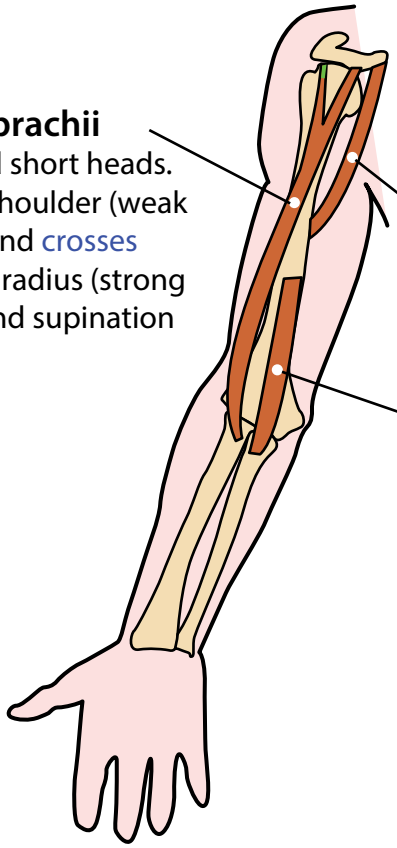


VIEWED FROM BELOW

RELATIONS OF BRACHIAL ARTERY

Medial: Upper half - ulnar nerve, basilic vein
Lower half - median nerve
Lateral: Upper half - median nerve, biceps
Lower half - biceps
Posterior: Upper third - triceps
Middle third - coracobrachialis
Lower third - brachialis

MUSCLES OF THE ANTERIOR ARM



Biceps brachii
Long and short heads.
Crosses shoulder (weak flexion) and crosses elbow to radius (strong flexion and supination

Coracobrachialis
Adductor
Crosses shoulder only
Weak (aided by gravity)

Brachialis
Crosses and flexes elbow only
Strong muscle
Plays no part in pronation/ supination

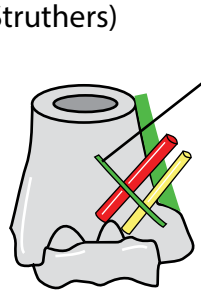
All supplied by Musculocutaneous nerve C5,6 (probably little if any C7 in it)

ANTERIOR ARM MUSCLES

Biceps
Origin:
Long head - Supraglenoid tubercle
Short head - coracoid
Insertion: Radial tuberosity and bicipital aponeurosis
Action: Flexes shoulder and elbow. Supinates
Nerve supply: Musculocutaneous

Brachialis
Origin: Anterior/lower 1/2 humerus and medial and lateral intermuscular septum
Insertion: Coronoid process and tubercle of ulna
Action: Flexes elbow
Nerve supply: Musculocutaneous and twig from radial

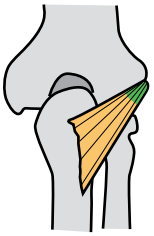
Coracobrachialis
Origin: Coracoid process
Insertion: Anteromedial humerus - mid shaft
Action: Adducts and flexes shoulder
Nerve supply: Musculocutaneous
Note: Coracobrachialis is the equivalent to the three adductors in the leg. It is thus vestigially tripartite and a third head may remain as a supratrochlear spur (ligament of Struthers)

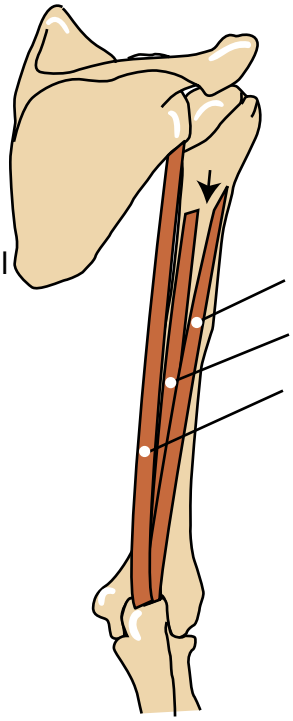


Brachial artery and median nerve

MUSCLES OF THE POSTERIOR ARM (EXTENSORS)

ANCONEUS
Origin: Lower lateral epicondyle
Insertion: Posterior/lateral ulna and olecranon
Action: Weak extensor. "Abducts" elbow in pronation
Nerve supply: Radial





3 HEADS OF TRICEPS

Lateral (lateral to spiral groove)

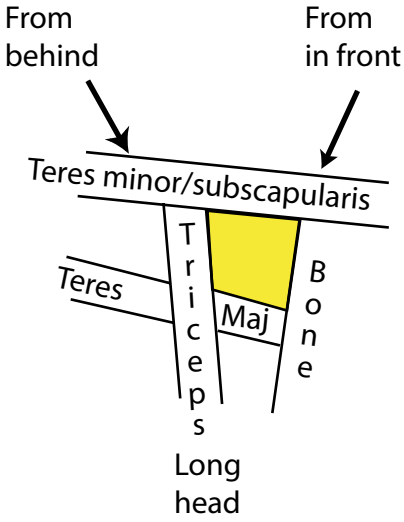
Medial (medial to spiral groove)

Long (infraglenoid tubercle)

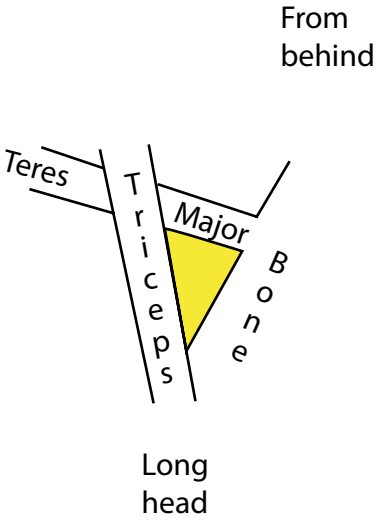
Spiral groove begins between the medial and lateral heads

TRICEPS:
All 3 heads insert into the olecranon. It extends the elbow, weakly extends the shoulder and the long head stabilises the shoulder.
Nerve: Radial (C7,8)

QUADRANGULAR AND TRIANGULAR SPACES

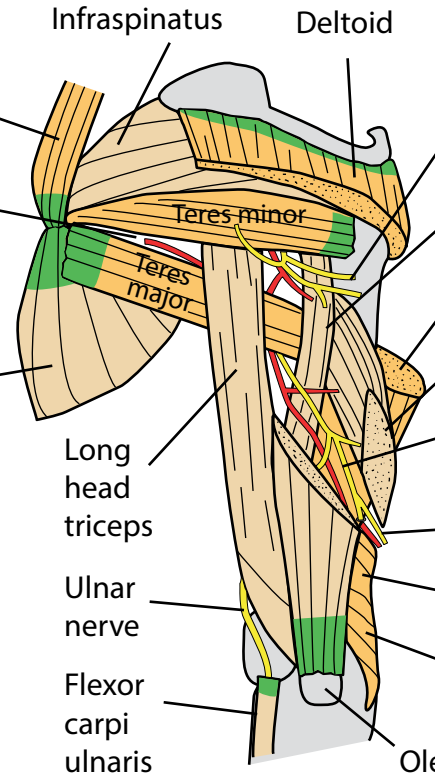


Quadrangular space



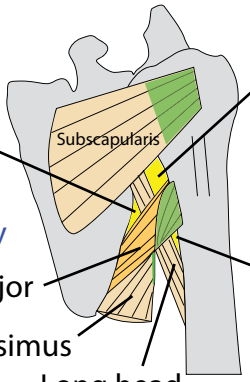
Lateral triangular space

POSTERIOR ARM MUSCLES AND SPACES



LLCNA - Lower lateral cutaneous nerve of arm
PCNFA - Posterior cutaneous nerve of forearm

QUADRANGULAR AND TRIANGULAR SPACES



Medial triangular space
Circumflex scapular artery
Teres major
Latissimus dorsi
Long head triceps

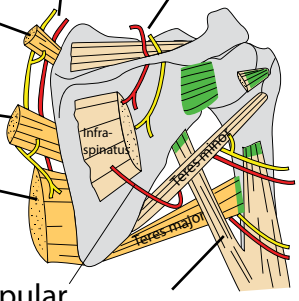
Quadrangular space
Axillary nerve and posterior circumflex humeral artery

Lateral triangular space
Radial nerve and profunda brachii artery

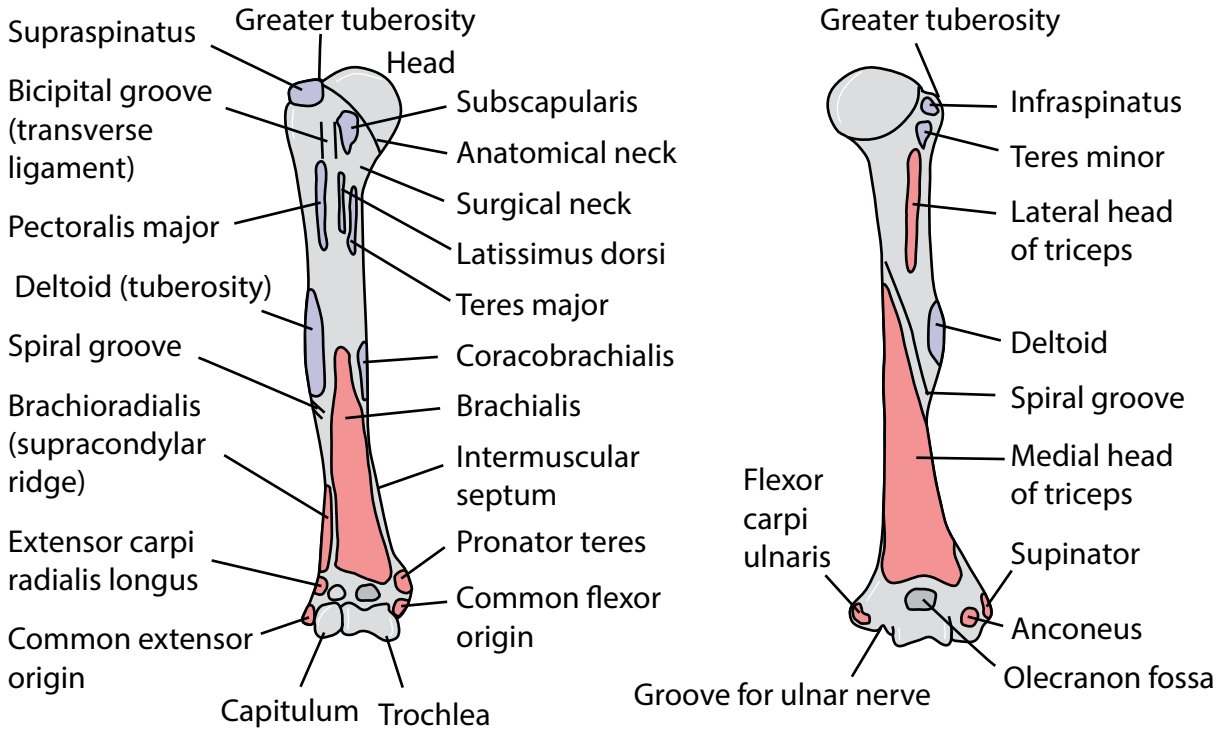
Viewed from in front

Viewed from behind

Dorsal scapular nerve and transverse cervical artery
Suprascapular artery and nerve
Levator scapulae
Rhomboid minor
Rhomboid major
Circumflex scapular artery
Long head of

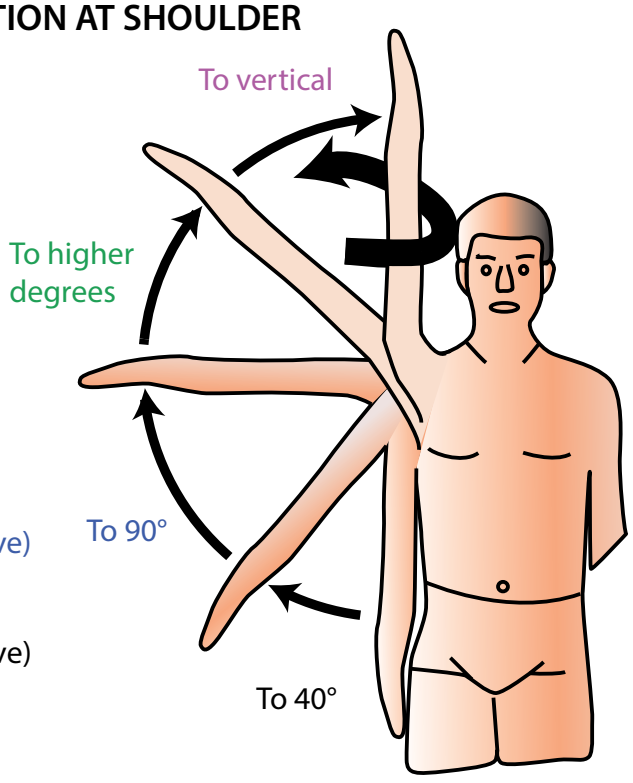


HUMERUS (MUSCLE ATTACHMENTS)

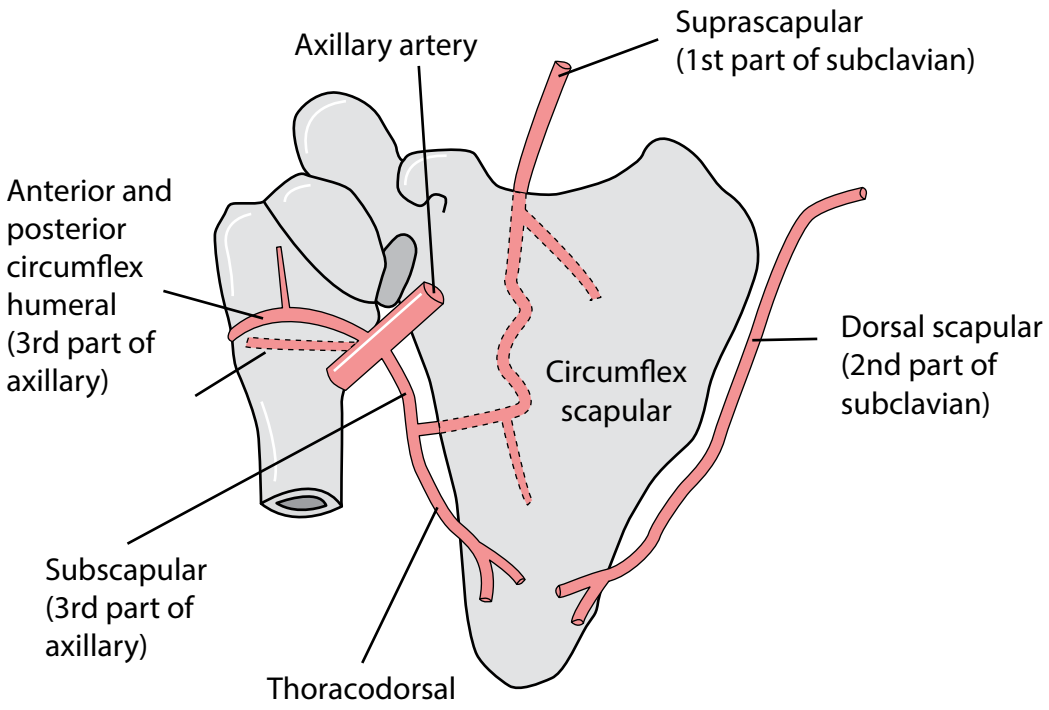


ABDUCTION AT SHOULDER

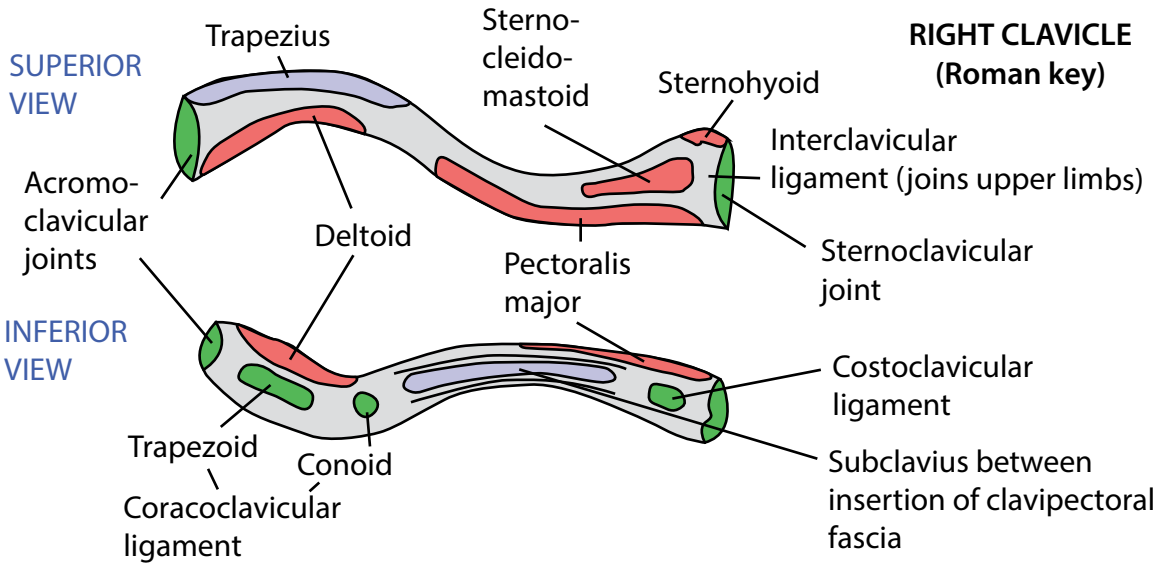
- External rotation: infraspinatus suprascapular nerve)
- Rotation of scapula: Trapezius (spinal XI) Serratus anterior - lower fibres (long thoracic nerve)
- Mostly deltoid (axillary nerve) Supraspinatus (suprascapular nerve)
- Supraspinatus (suprascapular nerve) and some deltoid (axillary nerve)



ARTERIAL ANASTOMOSIS AROUND SHOULDER



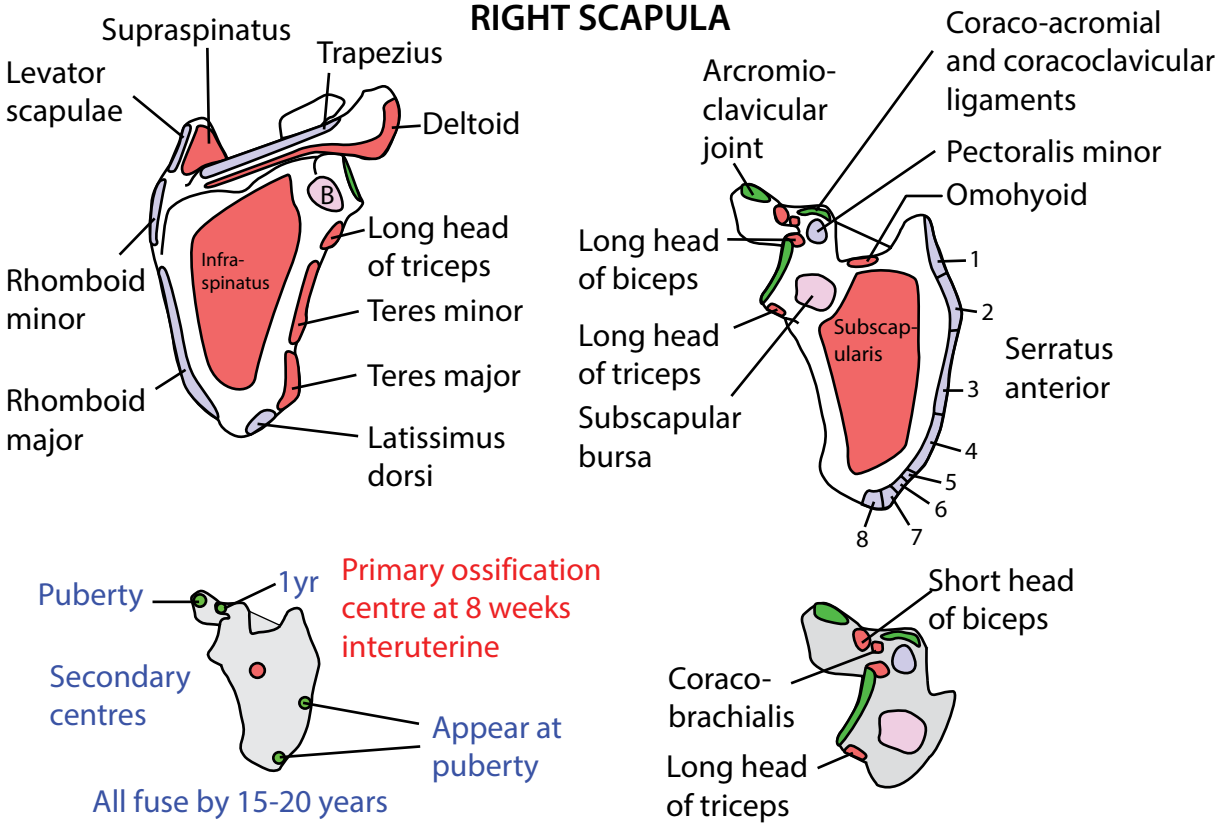
RIGHT CLAVICLE (Roman key)



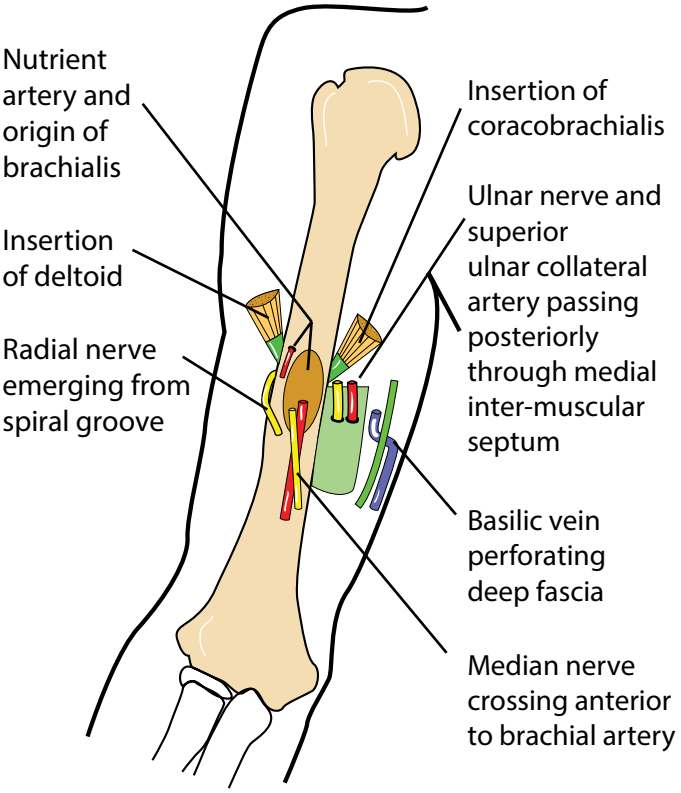
Ossifies in membrane, 1st to appear at 5 weeks intra-uterine. Only one secondary centre at sternal end, appearing in teens. One of the last to fuse at 26-30 years. No medullary cavity. Most fractures are indirect trauma. Occur at junction of lateral 1/3 and medial 2/3. Subclavius protects the vessels

Ligaments: Costoclavicular
Coracoclavicular
Sternoclavicular

RIGHT SCAPULA



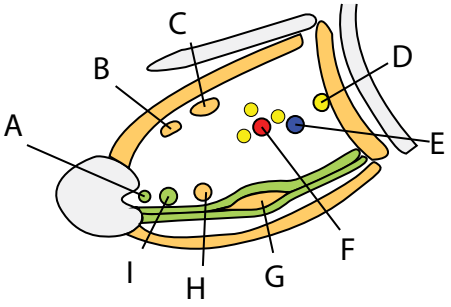
EVENTS OCCURING AT OR NEAR MID-HUMERUS



- Nutrient artery entering humerus
- Origin of brachialis
- Insertion of deltoid
- Insertion of coracobrachialis
- Radial nerve emerging from spiral groove
- Basilic vein perforating deep fascia
- Median nerve crossing anterior to brachial artery
- Ulnar nerve and superior ulnar collateral artery passing posteriorly through medial inter-muscular septum

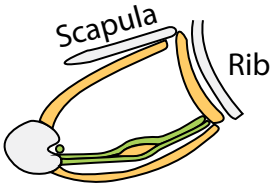
1.3 Axilla, Brachial Plexus and Nerve Lesions

CONTENTS

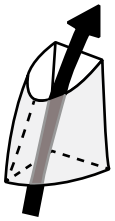


A - Long head of biceps
B - Latissimus dorsi
C - Teres major
D - Long thoracic nerve
E - Axillary vein
F - Axillary artery and cords
G - Pectoralis minor
H - coracobrachialis
I - Short head of biceps
+ Lymph nodes

AXILLA - between arm and thorax



A truncated cone

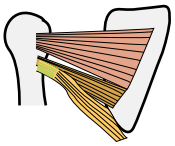


Apex
Clavicle
Scapula
Outer 1st rib

Floor
Axillary fascia which is held by suspensory ligament and lies between anterior and posterior axillary folds, deep fascia of arm and serratus anterior

Medial wall
Serratus anterior to 4th rib

Posterior wall

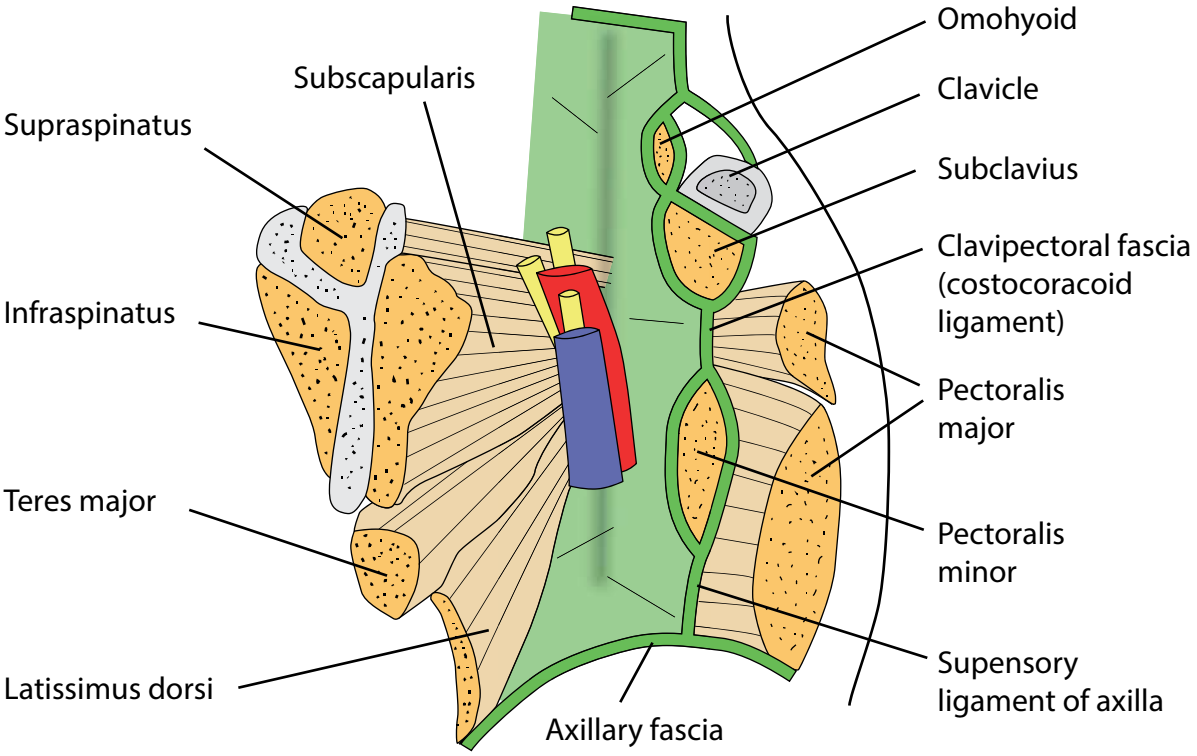


Subscapularis
Teres major
Latissimus dorsi

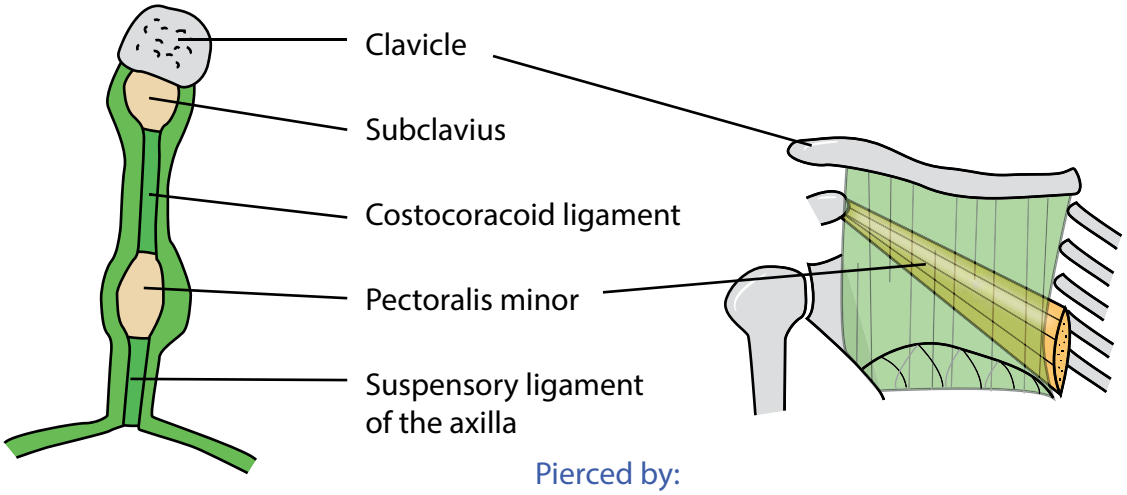
Lateral wall
Intertubercular (bicipital) groove
Biceps tendon

Anterior wall
Pectoralis major
Pectoralis minor
Clavipectoral fascia

LEFT AXILLA LOOKING LATERALLY



CLAVIPECTORAL FASCIA

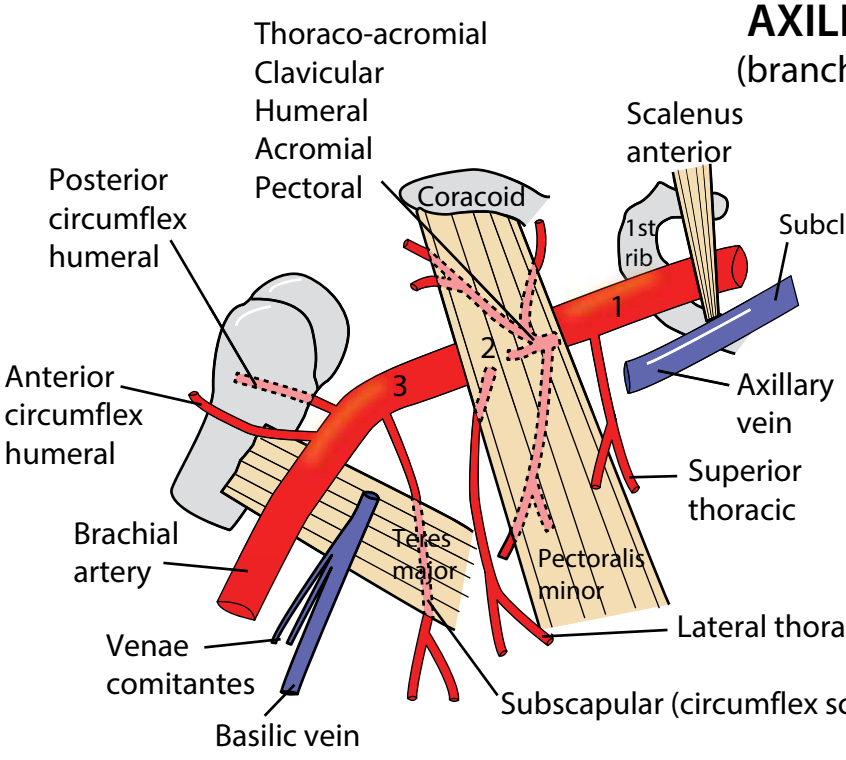


Pierced by:

- Acromiothoracic trunk
- Cephalic vein
- Lateral pectoral nerve
- Lymphatics

AXILLARY ARTERY 1

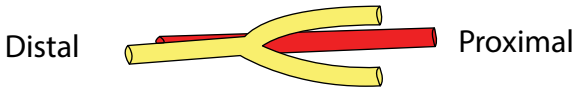
(branches from parts1-2-3)



Mnemonic for branches:
Some - Superior thoracic
Times - Thoraco-acromial
Life - Lateral thoracic
Seems - Subscapular
A - Anterior circumflex humeral
Pain - Posterior circumflex humeral

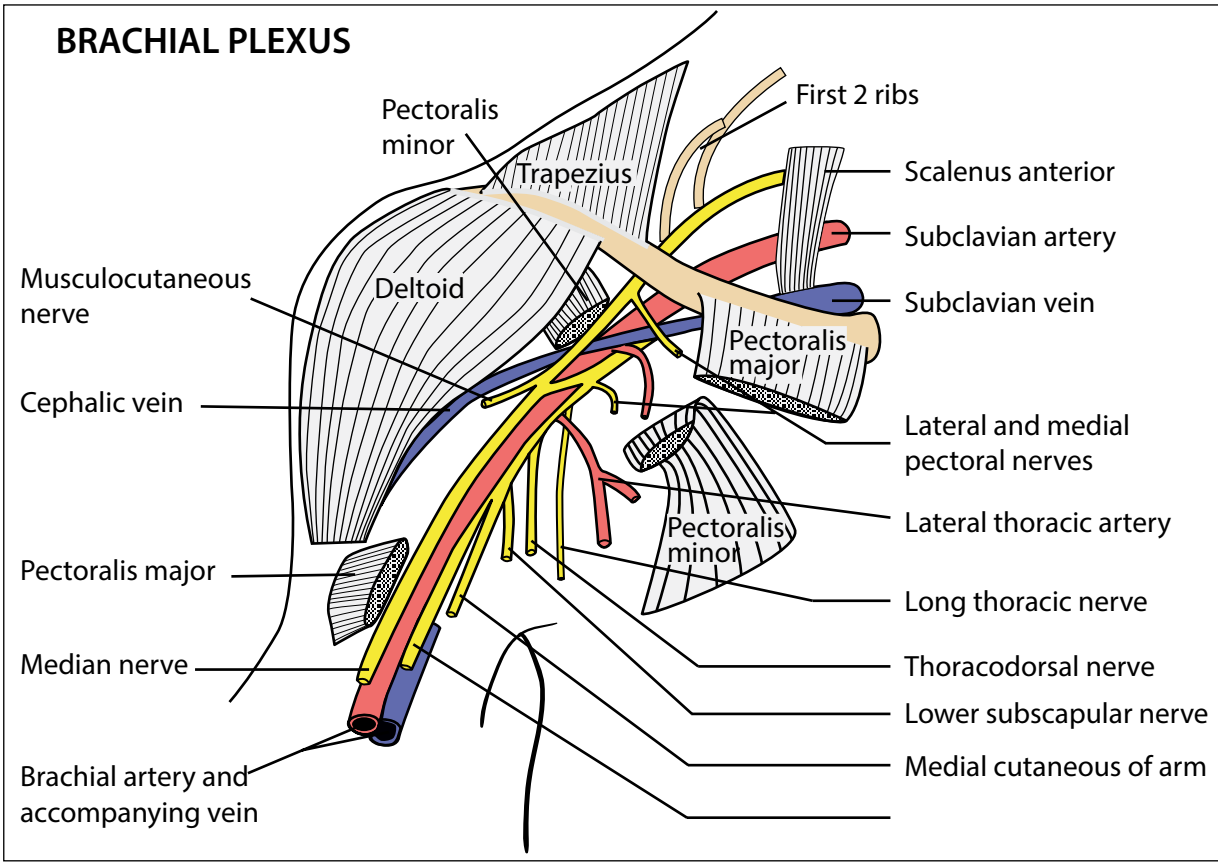
AXILLARY ARTERY 2
(branches from parts1-2-3)

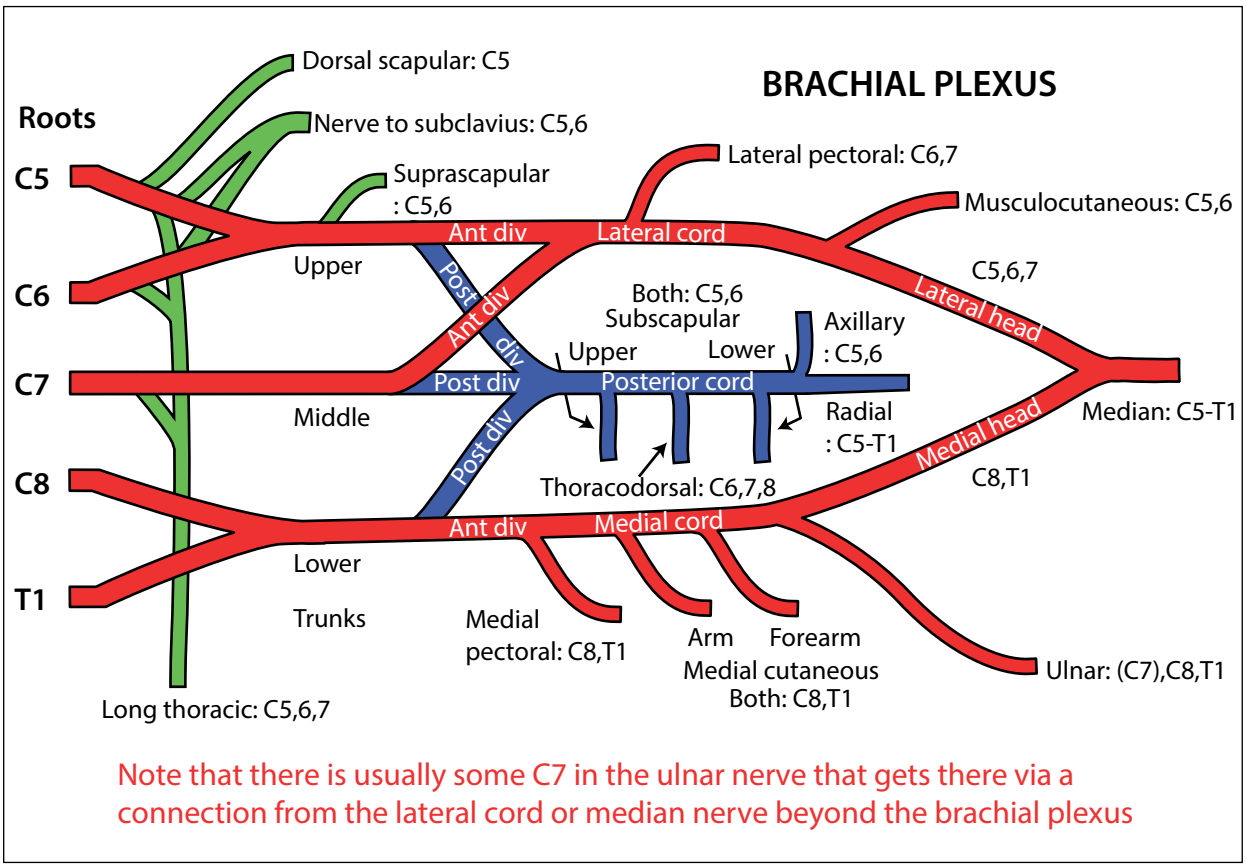
1st part: Outer border of 1st rib to medial edge of pectoralis minor
1 branch: Superior thoracic
Relations: 3 cords of brachial plexus lie laterally
2nd part: Behind pectoralis minor
2 branches: Thoraco-acromial, lateral thoracic
Relations: 3 cords around it according to their names
3rd part: lateral edge of pectoralis minor to lower border of teres major
3 branches: Subscapular, anterior and posterior circumflex humeral
Relations: Median nerve forming from its two heads anterior to artery



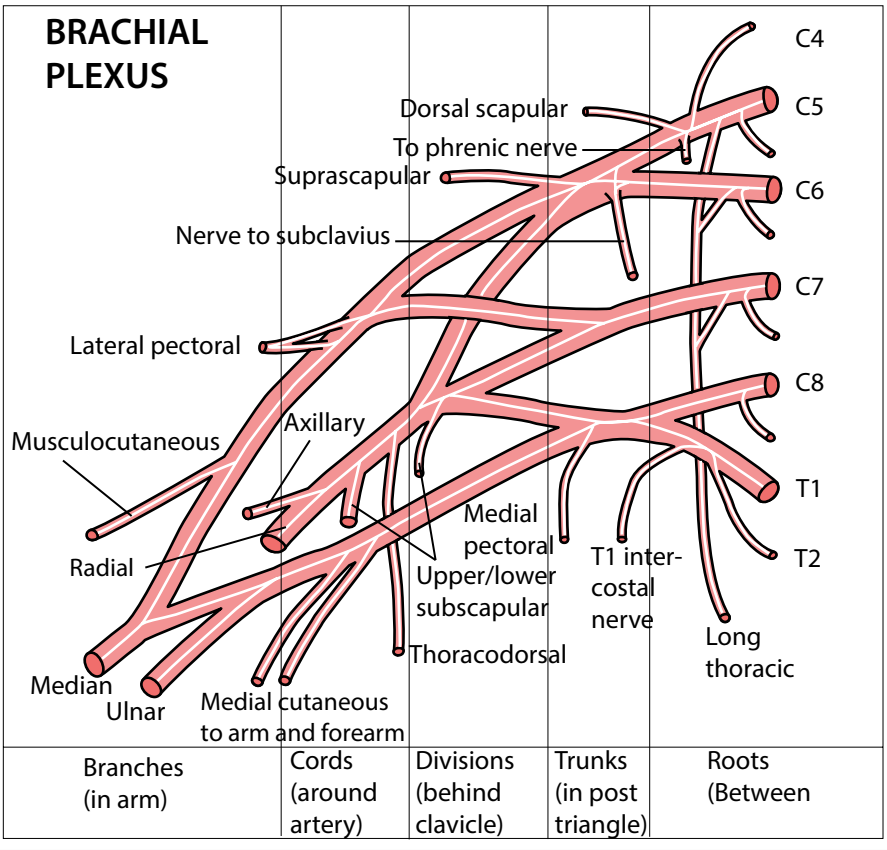
3rd part of artery with 2 heads of median nerve forming anterior to it.

BRACHIAL PLEXUS

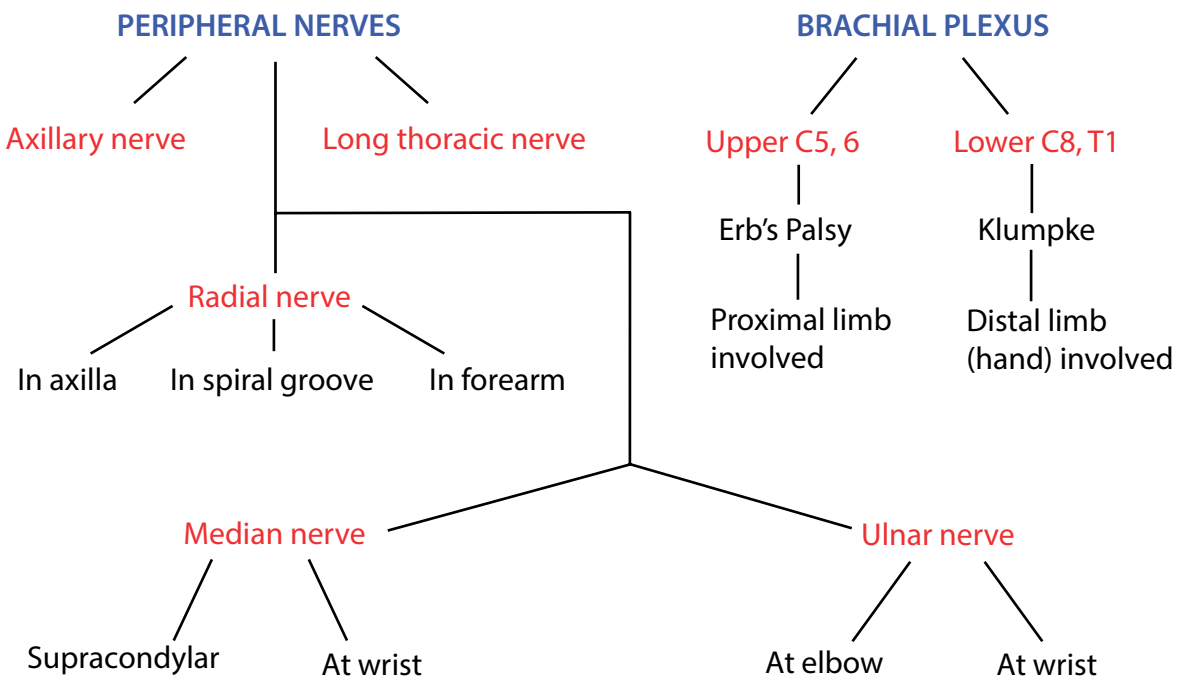




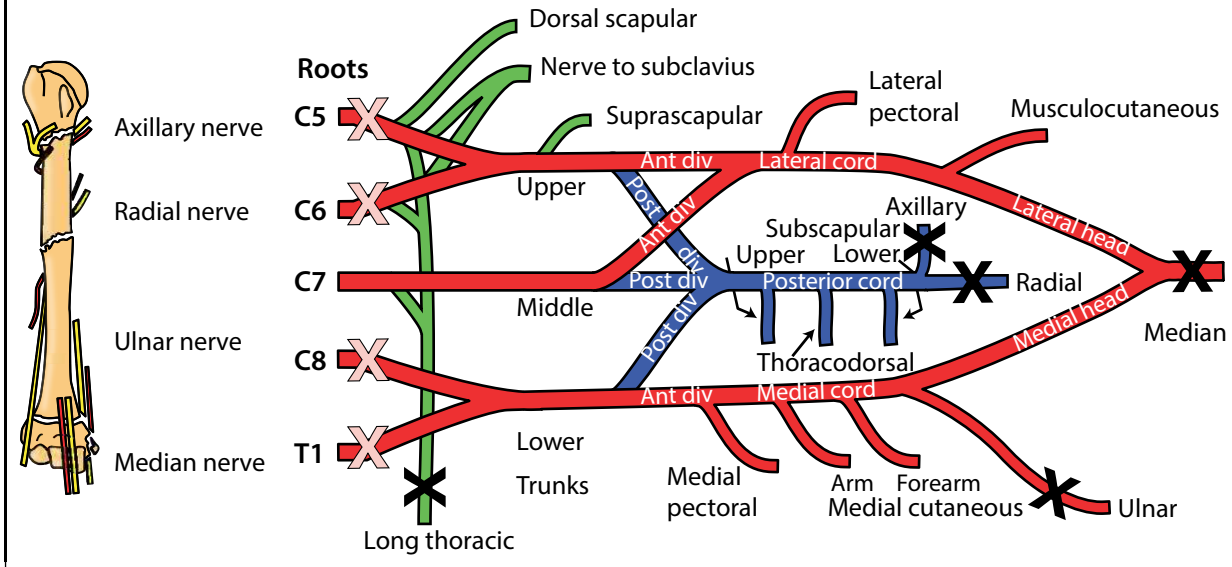
Note that there is usually some C7 in the ulnar nerve that gets there via a connection from the lateral cord or median nerve beyond the brachial plexus



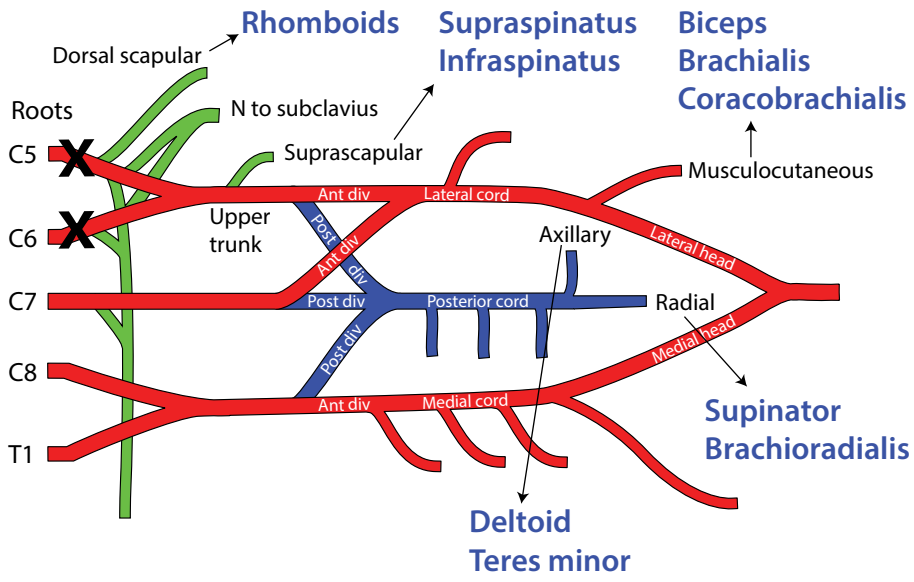
NERVE LESIONS IN THE UPPER LIMB



NERVE LESIONS IN THE UPPER LIMB



NERVE LESIONS: UPPER BRACHIAL PLEXUS - C5,6: 1



NERVE LESIONS: UPPER BRACHIAL PLEXUS - C5,6: 2

Aetiology: Birth traction (Erb Duchenne palsy) or adult trauma, (Erb's palsy) e.g. motorbike accident.

Muscle loss: Deltoid, short shoulder muscles, brachialis, biceps, supinator, brachioradialis.

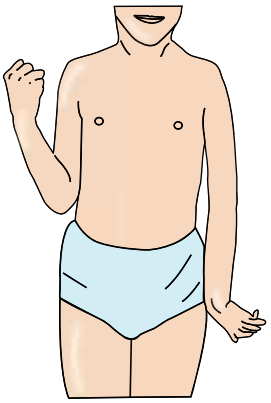
Movement loss: Abduction and external rotation of shoulder, supination, elbow flexion.

Dominated by: Latissimus dorsi (C6,7,8), pronator teres (C6,7), pectorals (C6,7,8).

Result: Atrophy, limpness of upper arm, internal rotation of shoulder, pronation of forearm, palm backwards - 'waiter's tip deformity'.

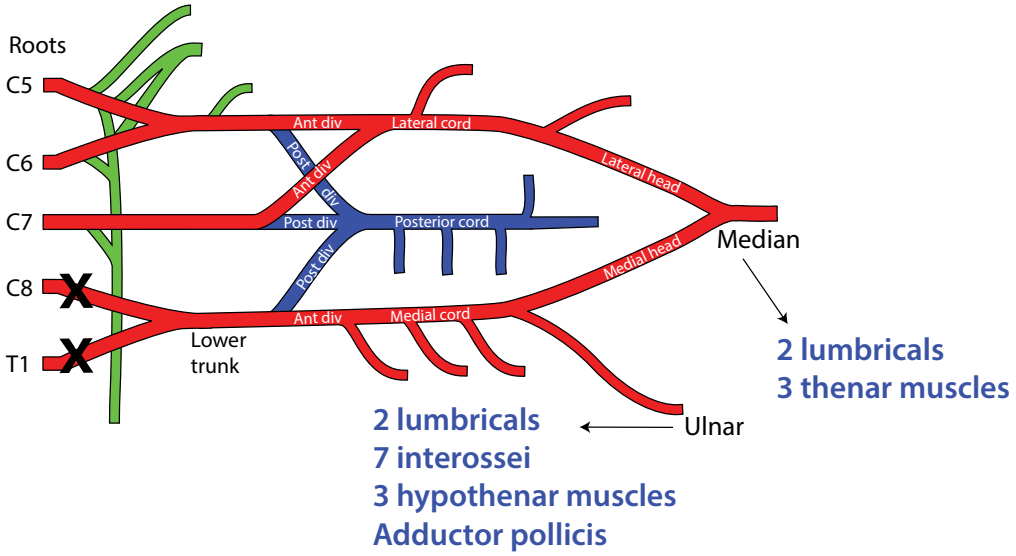
Sensory loss: C5 in upper and lower lateral cutaneous nerves of arm (respectively from axillary and radial). Only if C6 is involved will the lateral cutaneous nerve of forearm (musculocutaneous) be affected.

Summary: C5 controls shoulder flexion, abduction, lateral rotation and elbow flexion. C6 controls supination including supinator.



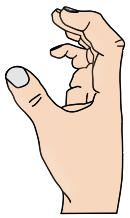
Left Erb's palsy

NERVE LESIONS: LOWER BRACHIAL PLEXUS - C8, T1: 1



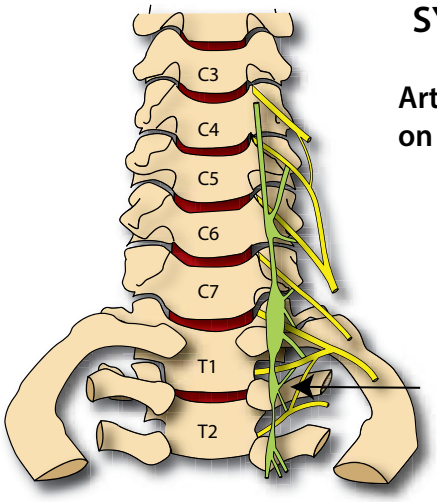
NERVE LESIONS: LOWER BRACHIAL PLEXUS - C8, T1: 2

Aetiology: Klumpke's palsy. Pull on arm at breech delivery (hyperabduction at shoulder), apical carcinoma of lung.
Muscle loss: Small muscles of hand - lumbricals and interossei, hypothenar, adductor pollicis.
Movement loss: Flexion at metacarpophalangeal joints and diminished extension at interphalangeal joints.
Dominated by: Long extensors acting on metacarpophalangeal joints and long flexors acting on interphalangeal joints.
Result: Clawed hand ('main en griffe'). Associated damage to sympathetic chain may give Horner's syndrome with ptosis, small pupil (miosis), flushed, dry face (anhydrosis).
Sensory loss: T1 distribution - lower (+ or - upper) inner arm and hand.
Test: Loss of bulk of 1st dorsal interosseous, inability to hold paper between outstretched fingers (see ulnar nerve lesions).
Note: C8 and T1 involvement by a cervical rib (see cervical rib image)



Look for evidence of a complete clawed-hand involving all fingers

SYMPATHETIC CHAIN IN LOWER NECK



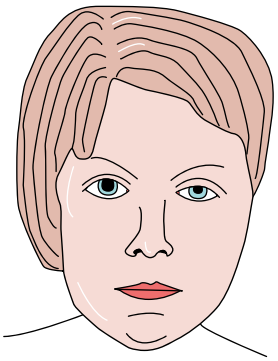
Arterial spasm may result from irritation of sympathetics on the subclavian artery from a cervical rib

SYMPATHECTOMY

Treatment of Raynaud's phenomenon by cutting the preganglionic sympathetic fibres at T2 and T3 to increase the blood flow to the fingers by preventing vasoconstriction

Small pupil
Mild ptosis
Flushed face
Dry face
Apparent enophthalmos

LEFT HORNER'S SYNDROME



PERIPHERAL NERVE INJURY

Causes: Direct trauma, ischaemia, traction, compression

Classification of nerve injury:

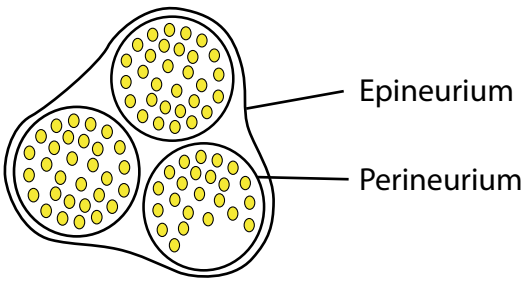
1. Neurotmesis. Complete or partial division of a nerve
2. Axonotmesis. Interruption of the axons without interruption of the sheath
3. Neuropraxia. Bruising or concussion of a nerve without damage to the axon or sheath, leading to temporary loss of function

Classification of muscle power:

0. No contraction
1. Flicker or trace of contraction
2. Active movement with gravity eliminated
3. Active movement against gravity
4. Active movement against gravity and resistance
5. Normal power

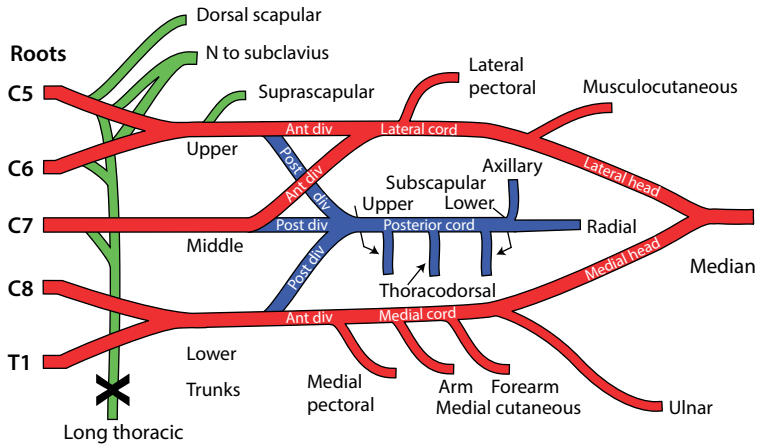
Axon with myelin sheath and neurolemma which is composed of Schwann cells

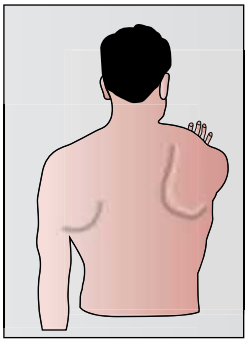
Structure of a nerve



NERVE LESIONS: LONG THORACIC NERVE (OF BELL) -C5, 6, 7

Aetiology: Damage during surgery in the axilla for axillary node clearance or sentinel node biopsy for breast cancer, or placement of a chest drain. Occasionally congenital.
Result: Loss of serratus anterior leading to 'winging' of scapula. Decreased flexion and abduction of arm due to loss of scapular rotation. Varying degrees of disability according to the site of the lesion.
Sensory loss: Nil.
Test: Patient presses against wall and scapula on side of lesion will 'wing' (protrude posteriorly).
Anatomy: Passes down on serratus anterior in the mid-axillary line.

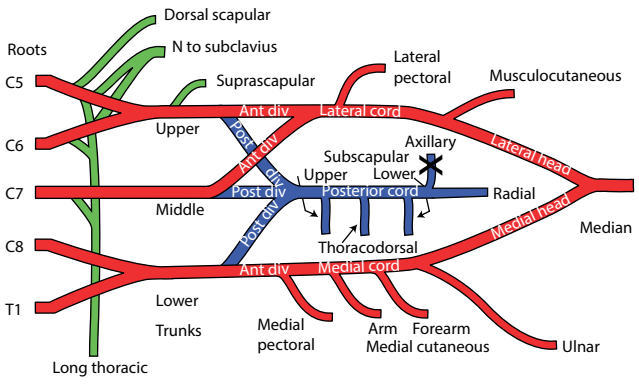


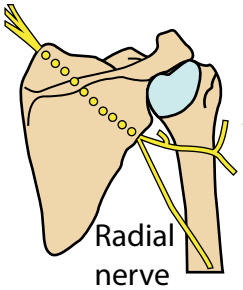


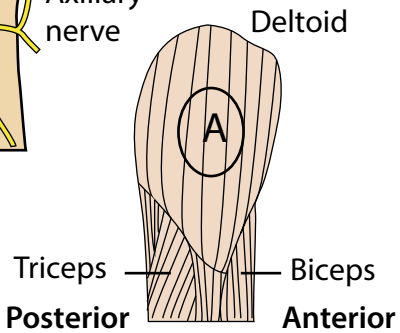
Right "winged" scapula whilst patient is pushing against wall

NERVE LESIONS: AXILLARY NERVE

Aetiology: Fractured neck of humerus or dislocation of shoulder (in 5% of dislocations)
Muscle: Loss of deltoid and teres minor
Movement loss: Diminished flexion, extension and abduction of shoulder.
Result: Wasting of deltoid
Sensory loss: Upper lateral cutaneous nerve of arm from its posterior branch. The autonomous area for this nerve is an area the size of a 'regimental patch' (A)
Test: For loss of sensation as indicated. In the acute clinical situation it is not practical to test for motor activity in deltoid







MEDIAN NERVE

FORMED: From two 'heads' in axilla, anterior to 3rd part of axillary artery. Crosses artery, usually anteriorly, from lateral to medial to lie medial to brachial artery in cubital fossa.

PASSES: Under biceps and onto or medial to brachialis, then between two heads of pronator teres, supplying it, and then under fibrous arch of flexor digitorum superficialis with ulnar artery. Under flexor digitorum superficialis, emerging from its lateral border to lie between tendons of flexor carpi radialis and palmaris longus. Passes deep to flexor retinaculum to reach palm of hand.

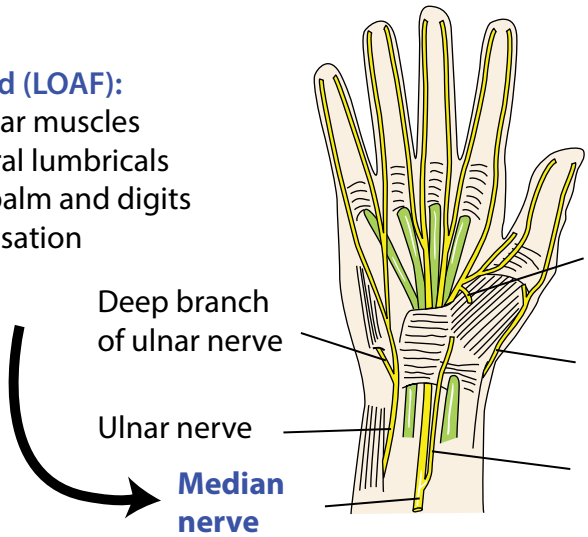
BRANCHES IN FOREARM: To flexor carpi radialis, palmaris longus and flexor digitorum superficialis. Via its anterior interosseous branch to flexor pollicis longus, half flexor digitorum profundus and pronator quadratus. Joint branches to elbow, wrist, superior and inferior radio-ulnar.

BRANCHES IN HAND: Sensory: Palmar cutaneous branch leaves the median nerve above the wrist and runs superficial to the flexor retinaculum to supply lateral palm skin. Main nerve in hand supplies palmar skin and dorsal nail beds of lateral 3 and half digits. Motor: lateral 2 lumbricals, abductor pollicis brevis, opponens pollicis and usually flexor pollicis brevis

MEDIAN NERVE

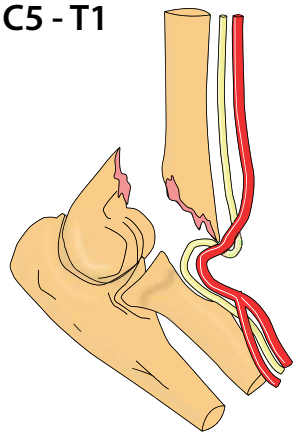
In forearm:
1. Pronator teres
2. Flexor carpi radialis
3. Palmaris longus
4. Flexor digitorum superficialis
5. Radial half of flexor digitorum profundus
6. Pronator quadratus

In hand (LOAF):
3 Thenar muscles
2 Lateral lumbricals
3 1/2 palm and digits for sensation



"LOAF": 2 lateral lumbricals, opponens pollicis,

NERVE LESIONS: MEDIAN NERVE - SUPRACONDYLAR - C5 - T1



Supracondylar Fracture at elbow

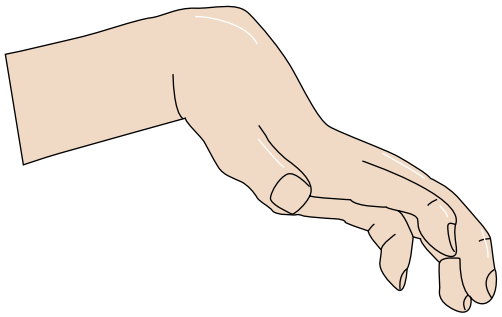
Aetiology: Supracondylar fracture/dislocation. (very rarely a tight bicipital aponeurosis, presence of a Struthers' Ligament or pronator syndrome where the median nerve is trapped between the two heads of pronator teres).
Muscle loss: Pronator teres, pronator quadratus, flexors of wrist/fingers (except flexor carpi ulnaris and ulnar half flexor digitorum profundus). Palmaris longus, two radial lumbricals and the 3 thenar muscles. Adductor pollicis is spared (ulnar nerve). Damage to the anterior interosseous nerve alone gives loss of flexor pollicis longus, flexor digitorum profundus to the index finger and middle fingers and pronator quadratus.
Movement loss: Loss of pronation, weak wrist flexion and abduction. Abduction of thumb is weak from loss of abductor pollicis brevis (abductor pollicis longus is intact). Loss of opposition of thumb (flexor pollicis longus). The thumb is virtually useless. Loss of flexor digitorum profundus to index and middle fingers and flexor digitorum superficialis to all four fingers.
Result: Ulnar deviation of wrist, thenar wasting, Papal benediction on attempting to make a "fist".
Sensory loss: Radial side of palm, radial 3 1/2 fingers and nail beds.
Test: Sensory - loss of pulp of index finger (autonomous area). Motor – loss of pronation of forearm, wrist flexion on the radial side, ability of thumb to abduct at right angles to palm (abductor pollicis brevis), opposition of thumb to index finger, flexion of interphalangeal joints of index and middle fingers and flexor pollicis longus by touching tip of thumb pulp to pulp of index. Flexion of the interphalangeal joints by flexor digitorum superficialis of index and middle fingers is assessed.

NERVE LESIONS: MEDIAN NERVE – AT WRIST– T1

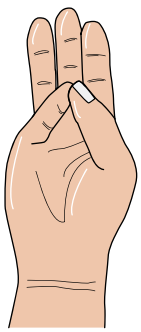
Aetiology: Wrist laceration, carpal tunnel syndrome and injury during surgery for it.
Muscle loss: 2 radial lumbricals and thenar muscles except adductor pollicis (ulnar nerve).
Movement loss: Abduction, opposition and flexion of thumb is impaired or lost making the thumb virtually useless. Adduction of thumb is intact. Some abduction of thumb is possible as abductor pollicis longus (radial nerve) is intact.
Result: Thenar wasting and some clawing of index and middle fingers.
Sensory loss: Radial side of palm, fingers and nail beds of radial 3 1/2 fingers. The palmar cutaneous branch of median nerve is usually spared if the compression is in the carpal tunnel leading to intact sensation of thenar skin. A more proximal lesion may well damage this palmar cutaneous nerve with loss of sensation over the thenar eminence. Any numbness is often preceded by periods of paraesthesia, a tingling sensation as a result of nerve compression.
Test: Sensory - loss of pulp of index finger (autonomous area). Motor - inability of thumb to abduct at right angles to palm (abductor pollicis brevis) and oppose thumb to index finger.

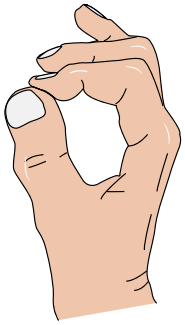
VOLKMANN'S ISCHAEMIC CONTRACTURE

Aetiology: Damage to brachial artery in supracondylar fracture. Ischaemia leading to contracture of long flexors and extensors in the forearm.
Result: Deformed hand. Muscles are replaced with fibrous tissue.
Wrist flexed - bulkier flexors therefore more contracture.
Extension of metacarpophalangeal joints because of insertion of extensor tendons into these joints.
Flexed interphalangeal joints because of insertion of long flexor tendons into these joints.



MEDIAN NERVE TESTING 1

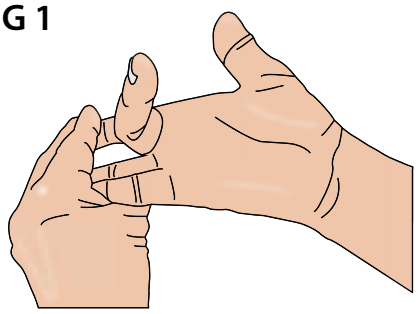




Inability to oppose index to thumb or little finger (loss of opponens pollicis).

Note: Trying to make a fist

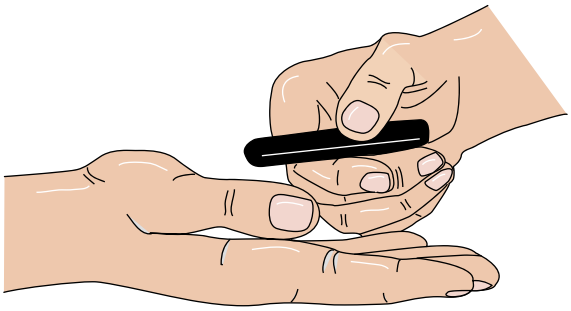
Papal benediction:
1. Thenar wasting
2. Ulnar deviation
3. Minimal flexion of digits 1-3



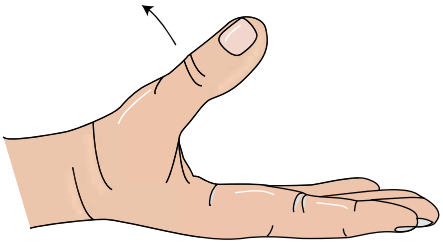
Testing the action of flexor digitorum superficialis (FDS) on the proximal interphalangeal joint (PIP). By stretching the tendons of flexor digitorum profundus (FDP) and the inter-tendinous connections to the other three fingers, the tendon of FDP to the middle finger is also effectively disabled. If FDS is intact the proximal interphalangeal joint can be flexed but there is inability to move the distal interphalangeal joint. This is the Quadriga phenomenon which shows that FDS is work

MEDIAN NERVE TESTING 2

Testing abductor pollicis brevis by asking patient to touch pen with thumb



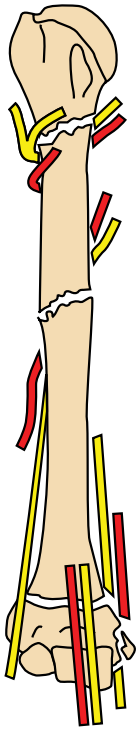
Assessment of the ability of abductor pollicis brevis to abduct the thumb at right angles to the palm. The muscle is always supplied by the median nerve



RADIAL NERVE 1

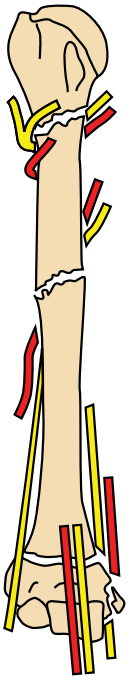
Midshaft fracture

Damage to radial nerve



Leaves: Axilla via lateral triangular space with profunda brachii artery
Spirals: Around posterior to upper fibres of the medial head of triceps, touching the humerus only in lower groove
Covered by: Upper fibres of brachialis
Passes through: Lateral intermuscular septum to reach the anterior compartment between brachialis and brachioradialis
To lie: Just lateral to the cubital fossa
Supplies: 3 cutaneous branches - posterior cutaneous nerves of arm and forearm; lower lateral cutaneous nerve of arm. Muscular branches to triceps, branchioradialis, extensor carpi radialis longus, anconeus and often a small twig to brachialis
Divides into: Posterior interosseus and superficial branch as it reaches supinator

RADIAL NERVE 2



Main branches:

Posterior interosseous: Off radial under branchioradialis, passes between the two heads of supinator and into extensor compartment. Lies on abductor pollicis longus then interosseous membrane.

Supplies all muscles in the extensor compartment of forearm (except those supplied by the radial nerve - see above) also sensory to deep structures but no cutaneous branches.

Superficial branch of radial: Lies under brachioradialis, over supinator, pronator teres and flexor digitorum superficialis. Passes out lateral/posterior to brachioradialis tendon, lateral to radial artery, posterior to radial styloid and then tendon of extensor pollicis longus as it forms the dorsal side of the snuff box. Several terminal branches to skin of the back of the hand and 3 1/2 fingers short of the nail beds.

NERVE LESIONS: RADIAL NERVE IN AXILLA – C5 – T1

Aetiology: Surgical damage, trauma and classically, but now rarely, crutch pressure.

Muscle loss: Triceps, extensors of wrist, fingers and thumb.

Movement loss: Extensor weakness at elbow, wrist and metacarpophalangeal joints. Minimal loss of supination as biceps is intact.

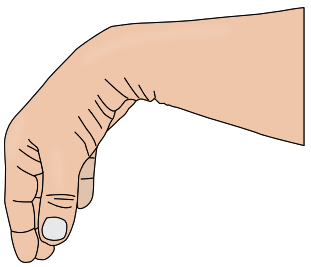
Result: Wrist drop with loss of power grip as digit extensors are held elongated and flexors shortened.

Sensory loss: Over first dorsal web space (autonomous area), dorsal aspect of the radial 3 1/2, +/- lower lateral cutaneous nerve of arm. There may also be detectable sensory loss over posterior aspect of arm and forearm.

Test: Sensation as above. Power of brachioradialis, extension of wrist and elbow against resistance.

Anatomy: Branches of the radial nerve are mostly given off well before they reach the muscles that they supply.

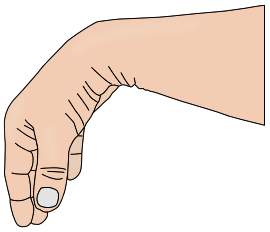
Wrist drop



NERVE LESIONS: RADIAL NERVE IN SPIRAL GROOVE – C5 – T1

Aetiology: Fracture mid-shaft humerus, Saturday night palsy and injections.
Muscle loss: Extensors of wrist, fingers and thumb, but triceps is spared. Extensor carpi radialis longus (ECRL) and brachioradialis may also be spared depending on the exact level of the injury. Loss of anconeus would probably be clinically insignificant but may give some instability in pronation and supination.
Movement loss: Extensor weakness of wrist and digits.
Result: Extension of elbow is normal, but the presence of wrist drop and loss of power grip will depend on whether ECRL is lost.
Sensory loss: Over 1st dorsal web space as for higher lesion. Lower lateral cutaneous nerve of arm is usually spared.
Test: Power of wrist extension.
Anatomy: **ECRL is the most important muscle for wrist extension and is the first wrist extensor to be innervated by the radial nerve. Its fate determines the presence or absence of wrist drop.**

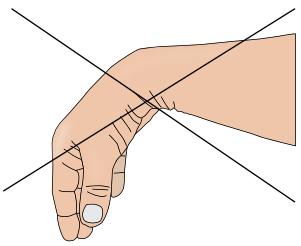
Wrist drop is likely



NERVE LESIONS: RADIAL NERVE (POSTERIOR INTEROSSEOUS N) IN FOREARM – C7, 8

Aetiology: Lateral or posterior forearm trauma, surgical mishap or fracture/dislocation of radial head.
Muscle loss: Extensors of wrist and fingers, but extensor carpi radialis longus is spared.
Movement loss: Extensor weakness of metacarpophalangeal joints. Interphalangeal joints are normal because of intact interossei and lumbricals.
Result: No wrist drop. Grip is normal as extensor carpi radialis longus is intact. Extension of elbow is normal.
Sensory loss: No sensory loss if superficial radial nerve is intact.
Test: Power of extension of metacarpophalangeal joints.

No wrist drop



ULNAR NERVE

IN ARM AND FOREARM

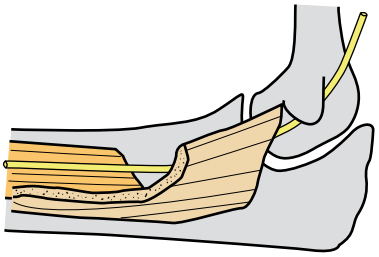
Passes: Posterior to the axillary vessels and through the medial intermuscular septum with the superior ulnar collateral artery and branches of the radial nerve which supply the medial head of triceps.

Progresses: Posterior to medial epicondyle of humerus and between the two heads of flexor carpi ulnaris and against the medial ligament of the elbow.

Continues: Under flexor carpi ulnaris and on flexor digitorum profundus with the ulnar artery lateral to it. It emerges lateral to the tendon of flexor carpi ulnaris at the wrist and passes into the hand superficial to the flexor retinaculum (Canal of Guyon) as a deep and superficial branch.

Gives: Dorsal cutaneous branch whilst still under the flexor carpi ulnaris which supplies the medial skin of dorsum of hand and one and a half digits. Also give a palmar cutaneous branch to the medial palmar skin.

Supplies: Flexor carpi ulnaris, the elbow joint and the medial half of flexor digitorum profundus in the forearm.



IN HAND

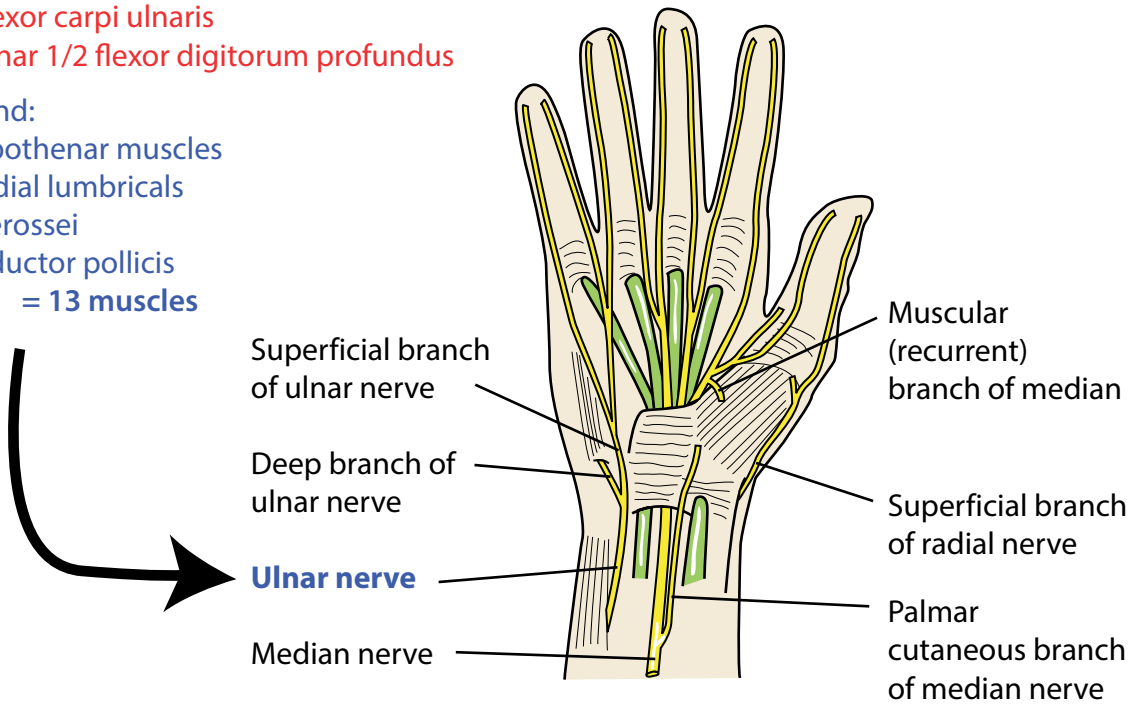
Superficial branch: Supplies palmaris brevis and skin of palmar one and a half digits.

Deep branch: Passes over the hook of hamate and supplies: wrist joint, flexor digiti minimi, abductor digiti minimi, opponens digiti minimi, all 7 interossei, 2 medial lumbricals and ends in and supplies adductor pollicis. It sometimes supplies flexor pollicis brevis.

ULNAR NERVE

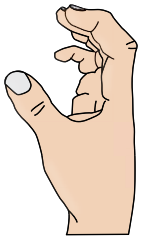
In forearm:
Flexor carpi ulnaris
Ulnar 1/2 flexor digitorum profundus

In hand:
3 Hypothenar muscles
2 Medial lumbricals
7 Interossei
1 Adductor pollicis
= 13 muscles



NERVE LESIONS: ULNAR AT ELBOW – (C7), C8, T1

Aetiology: Present or previous fractures or dislocation of elbow, damage behind medial epicondyle. Pressure on operating table. Entrapment between the two heads of flexor carpi ulnaris.
Muscle loss: All intrinsic muscles of hand (except radial 2 lumbricals and three thenar muscles), flexor digitorum profundus to ring and little fingers, flexor carpi ulnaris.
Result: Clawing, loss of grip and loss of abduction and adduction of fingers BUT less clawing of index and middle fingers because of intact two radial lumbricals. Note also that there is less clawing of ring and little fingers than with a lesion at the wrist due to loss of flexor digitorum profundus to these fingers. There is also radial deviation.
Sensory loss: Ulnar side of palmar and dorsal aspects of the hand and ulnar one and a half fingers.
Test: Assess grip of paper between fingers and ability to splay fingers under resistance. Froment's test to judge power of adductor pollicis. Assess wasting of 1st dorsal interosseous muscle. Test distal interphalangeal joint of little finger for ulnar 1/2 of flexor digitorum profundus.
Test sensation of little finger pulp (autonomous area).



Claw Hand

NERVE LESIONS: ULNAR AT WRIST -T1

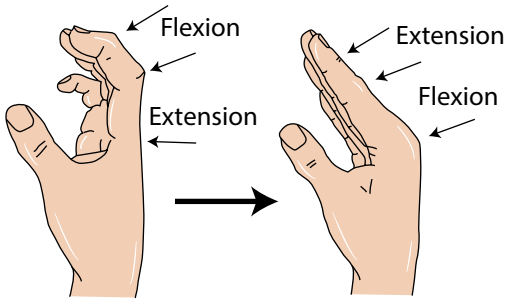
Aetiology: Lacerations at wrist, damage within Canal of Guyon or direct trauma to palm of hand damaging deep motor branch.
Muscle loss: All intrinsic muscles of hand except radial 2 lumbricals and three thenar muscles. Flexor digitorum profundus and flexor carpi ulnaris are intact.
Result: Clawed hand (no interossei therefore no flexion of metacarpophalangeal joints but instead they are extended at the metacarpophalangeal joints by long extensors. There is flexion of interphalangeal joints by long flexors. Absent radial deviation.
Note: LESS clawing of index and middle fingers because of intact median nerve to radial lumbricals but MORE clawing of ring and little fingers because of intact ulnar 1/2 flexor digitorum profundus than for an ulnar lesion at elbow (**ulnar paradox**).
Sensory loss: Ulnar 1 1/2 fingers. Dorsal and palmar cutaneous branches may be spared depending on the exact level of the injury.
Test: Assess grip of paper between fingers and ability to splay fingers under resistance. Froment's test to judge power of adductor pollicis. Assess wasting of 1st dorsal interosseous muscle. Test sensation of pulp of little finger (autonomous area).

Clawed Hand

EXPLANATION OF CLAWING

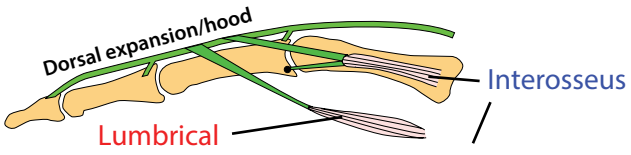
The key to understanding clawing is to appreciate that the first attachment of extensor digitorum to the dorsal hood is at the dorsal base of the proximal phalanx (see later image). The primary action of this muscle is to extend the metacarpophalangeal joint. Whereas extension of the proximal and distal interphalangeal joints is mediated predominantly by the dorsal and palmar interossei and lumbricals. If these small muscles of the hand are no longer active, as in an ulnar nerve lesion, then the extensor digitorum, unopposed, will forcefully overextend the metacarpophalangeal joint (see left lower image). Meanwhile the long flexor tendons flex the interphalangeal joints as they are powerful and overcome any attempted extension at these joints by extensor digitorum.

ACTION OF THE INTEROSSEI AND LUMBRICALS



LUMBRICAL AND INTEROSSEI MUSCLES

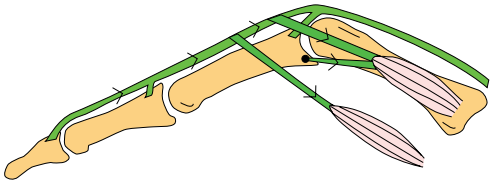
Note: The lumbricals reach the fingers on their radial side and they cross the metacarpophalangeal joints on their palmar aspect at an angle that allows flexion of these joints. Their attachments to the extensor expansions (dorsal hoods) allows simultaneously extension of the interphalangeal joints.
However, as the interossei are more in line with the metacarpals (see image below) they can only achieve the same actions as the lumbricals by having two tendons – one to the dorsal hood and the other to the base of the proximal phalanx.



Attached from **tendon** (Flexor digitorum profundus) to **tendon** (dorsal expansion)

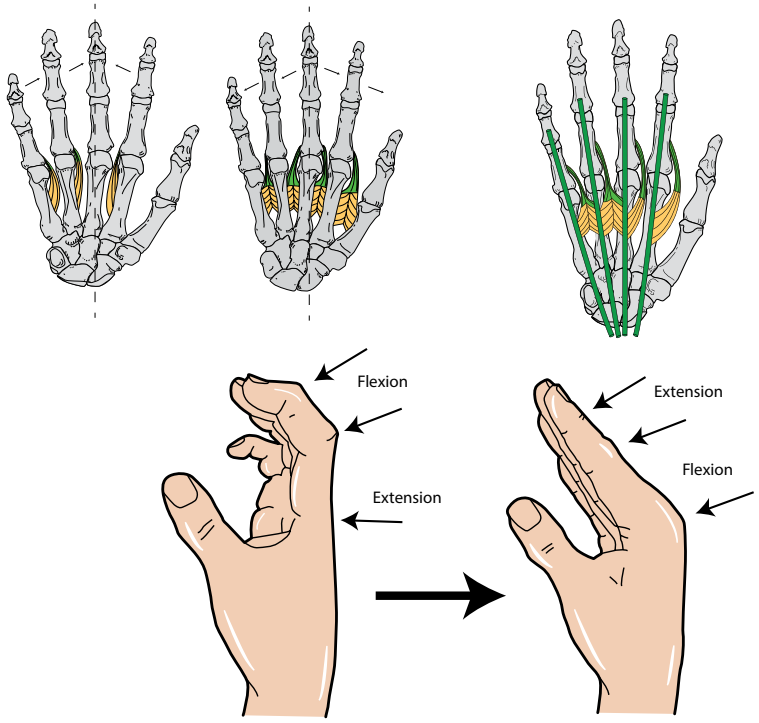
Attached to **bone** (base of proximal phalanx) AND **tendon** (dorsal expansion)

ACTION OF LUMBRICALS AND INTEROSSEI

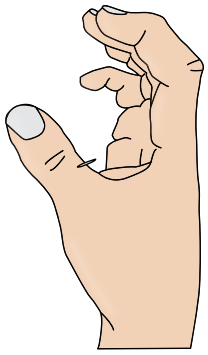


Flex metacarpophalangeal joints
Extend interphalangeal joints

ACTION OF THE INTEROSSEI AND LUMBRICALS



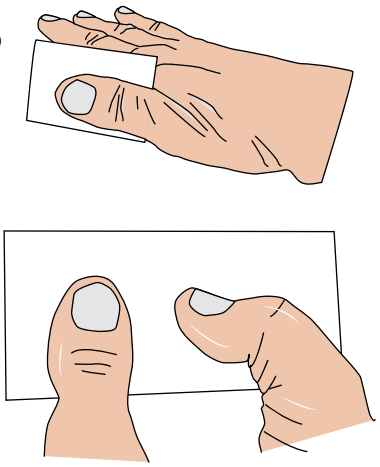
ULNAR NERVE TESTING 1



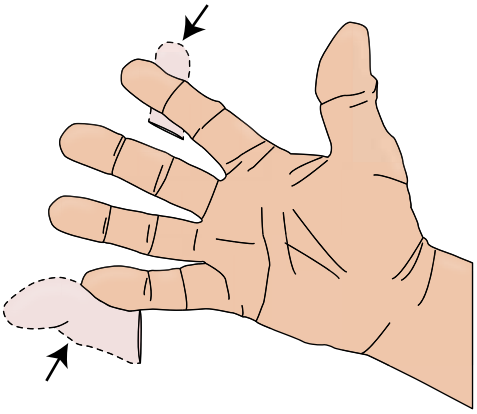
Clawing of hand is more marked in an ulnar lesion at the wrist as the long flexors are intact. "Ulnar paradox"

FROMENT'S TEST

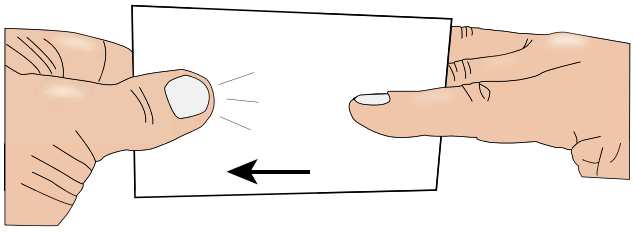
Paper is pinched in the first web space between the proximal phalanx of the thumb and the metacarpophalangeal joint of the index finger, with the digits extended. Adductor pollicis is being tested. The patient may "cheat" by using flexor pollicis longus (median nerve)



ULNAR NERVE TESTING 2



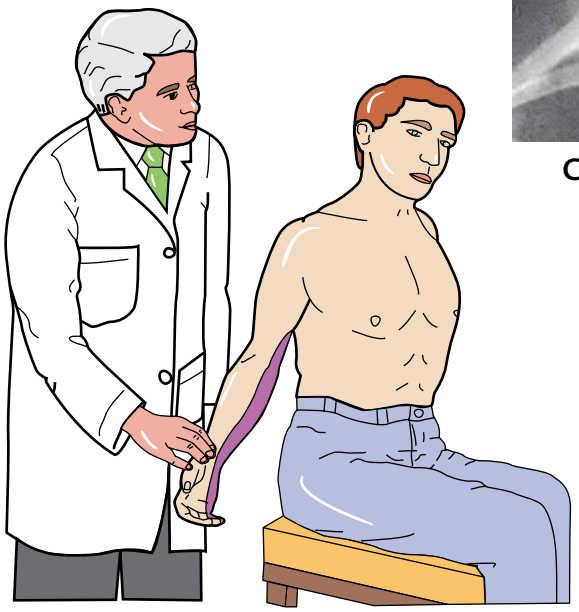
Attempt to splay (abduct) fingers against resistance using dorsal interossei



Testing the ability of the palmar interossei to adduct the fingers

EXAMINATION FOR CERVICAL RIB

1. Diminution of pulse
2. Paraesthesia in shaded area
3. Reproduction of symptoms on pulling arm downwards
4. Weakness of small muscles of the hand



Cervical rib

SUMMARY OF MYOTOMES IN UPPER LIMB

SHOULDER:	
Flexion/abduction/lateral rotation	C5
Extension/adduction/medial rotation	C6,7,8
ELBOW:	
Flexion (biceps reflex)	C5,6
Extension (triceps reflex)	C6,7,8
FOREARM:	
Pronation	C7,8
Supination	C6
WRIST:	
Flexion/extension	C7,8
FINGERS/THUMB (LONG TENDONS):	
Flexion/extension	C7,8
HAND (SMALL MUSCLES)	
All movements	T1

MUSCULOCUTANEOUS NERVE

PASSES:

Between conjoined heads of coracobrachialis then between biceps and brachialis

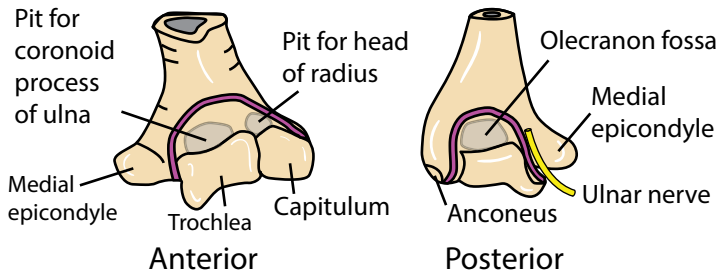
SUPPLIES:

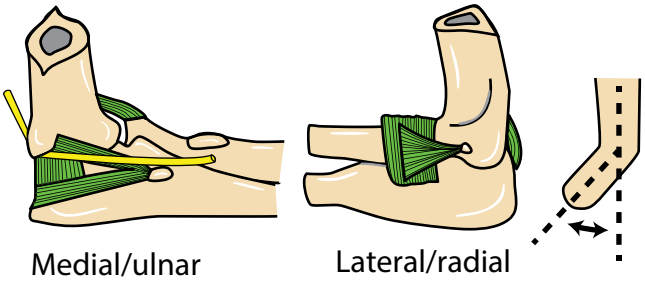
Motor - coracobrachialis, biceps and brachialis

Sensory - elbow joint and then lateral cutaneous nerve of forearm after emerging on lateral side of biceps

1.4 Elbow and Forearm

Capsule attachments





Medial/ulnar collateral ligament
Anterior, posterior and oblique parts

Lateral/radial collateral ligament
Lateral ligament
Anular ligament (blends with lateral lig and capsule)

ELBOW JOINT (lower left humerus)

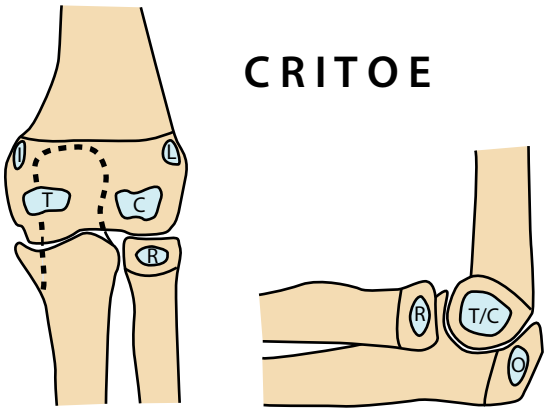
Synovial, hinge joint. Communicates with superior radioulnar joint
Carrying angle 170°, wider in females. Allows flexion of hand to mouth
Extension: Triceps
Flexion: Biceps, brachialis, brachioradialis, all muscles off common flexor origin

Anular ligament: Attaches to margins of radial notch. It blends with capsule and lateral ligament

Anterior: Brachialis, biceps tendon, brachial artery, median nerve

OSSIFICATION OF THE HUMERUS

Primary centre in mid shaft at 8 weeks intra-uterine. Secondary centre in head, greater and lesser tuberosities at 1 year. Note: Bone growth in upper limb is at upper humerus and at lower radius and ulna



OSSIFICATION CENTRES AT ELBOW

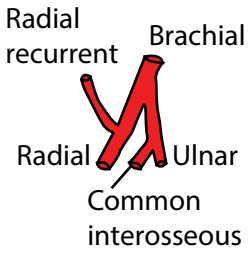
CRITOE

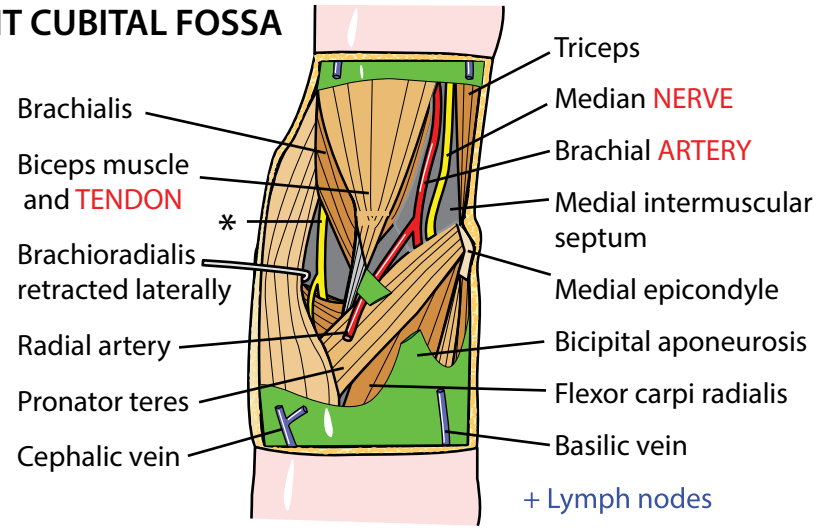
Lower end and elbow is more complex and is remembered best with the following mnemonic in the order in which they appear:

2 years	**C**apitulum
4 years	**R**adial head
6 years	**I**nternal (medial) epicondyle
8 years	**T**rochlea
10 years	**O**lecranon
12 years	**E**xternal (lateral) epicondyle

RIGHT CUBITAL FOSSA

* Radial nerve entering between heads of supinator to become post interosseous nerve and superficial branch passing down under brachioradialis



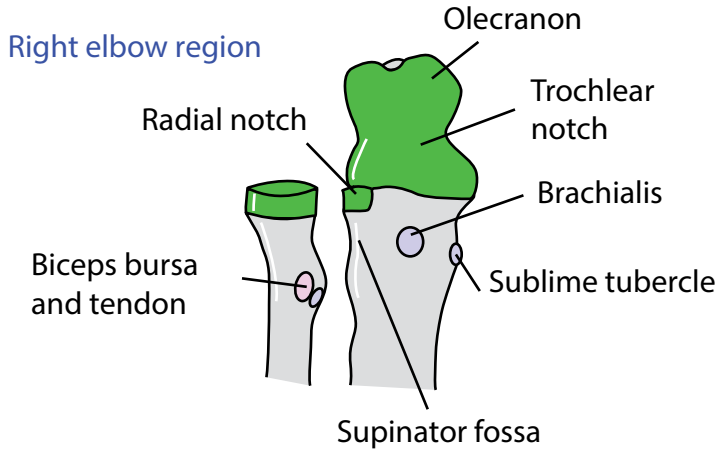


Site: Triangular space in anterior aspect of arm.
Borders: superior - intercondylar line: medial - lateral border of pronator teres: lateral - medial border of brachioradialis: floor - brachialis, supinator: roof - fascia.

Contains: From lateral to medial: biceps **T**endon, brachial **A**rtery and its accompanying veins, median **N**erve (i.e. **T.A.N.** - Tendon - Artery - Nerve), radial and post interosseous and superficial radial nerves under edge of brachioradialis. In fascia of roof are median basilic and cephalic veins, medial and lateral cutaneous nerves of forearm

PRONATION AND SUPINATION

AXIS: RADIAL HEAD - ULNAR STYLOID - LITTLE FINGER



ULNAR "ABDUCTION":
Anconeus
ULNAR "ADDUCTION":
Pronator teres (humeral head)

Note that the true axis of the forearm is through the mid-intercondylar point and the mid-interstyloid point - Thus, through the middle finger. Therefore in FREE pronation and supination the ulna is adducted and abducted whilst the radius rotates around it. This allows the hand to remain still in space

RADIO-ULNAR JOINTS

SUPERIOR

Continuous with elbow joint

Nerve supply: Anterior and posterior interosseous and median nerves

Anular ligament: Around neck, attached to edges of radial notch on ulna, not attached to radius. Blends with capsule above

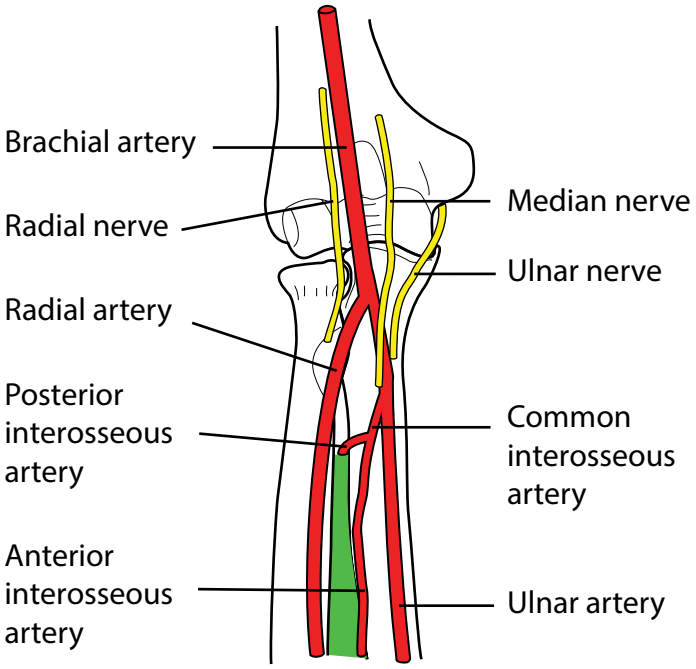
Quadrate ligament: Neck of radius to supinator fossa of ulna. Criss-cross fibres

Relations: Anterior - Supinator and radial nerve
Posterior - Supinator

INFERIOR

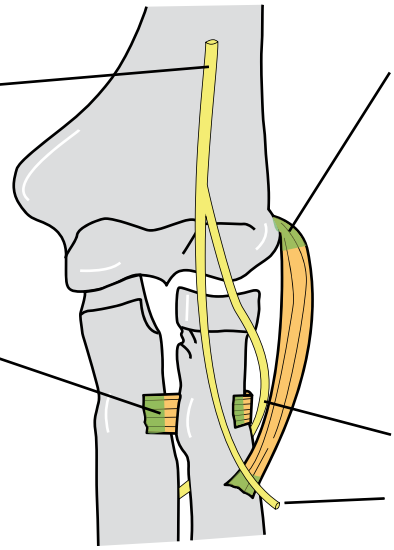
- Separated from wrist joint by triangle of fibrocartilage attached at its base to the radius and its apex to the ulnar styloid
- Loose capsule pouches upwards to give a sacciform recess by pronator quadratus

PASSAGE OF NERVES AND ARTERIES IN THE RIGHT ELBOW REGION



Arteries may pass between two bones (posterior interosseous artery passes between ulna and radius) Nerves alway

LEFT SUPINATOR AND ITS RELATION TO THE RADIAL NERVE



Radial nerve

SUPERFICIAL HEAD
Arises: lateral epicondyle and lateral and anular ligaments

Inserts: neck and shaft of radius between anterior and posterior oblique lines

Nerve: posterior interosseous from radial

DEEP HEAD
Arises: supinator crest and fossa

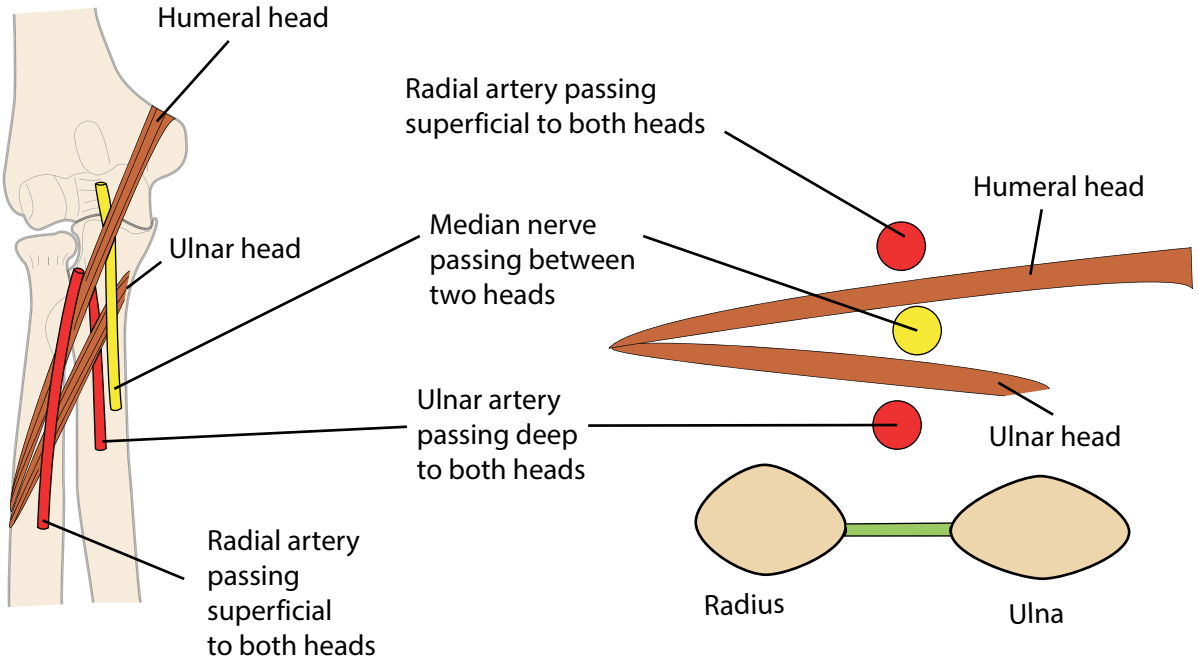
Posterior interosseous nerve

Superficial branch of radial nerve

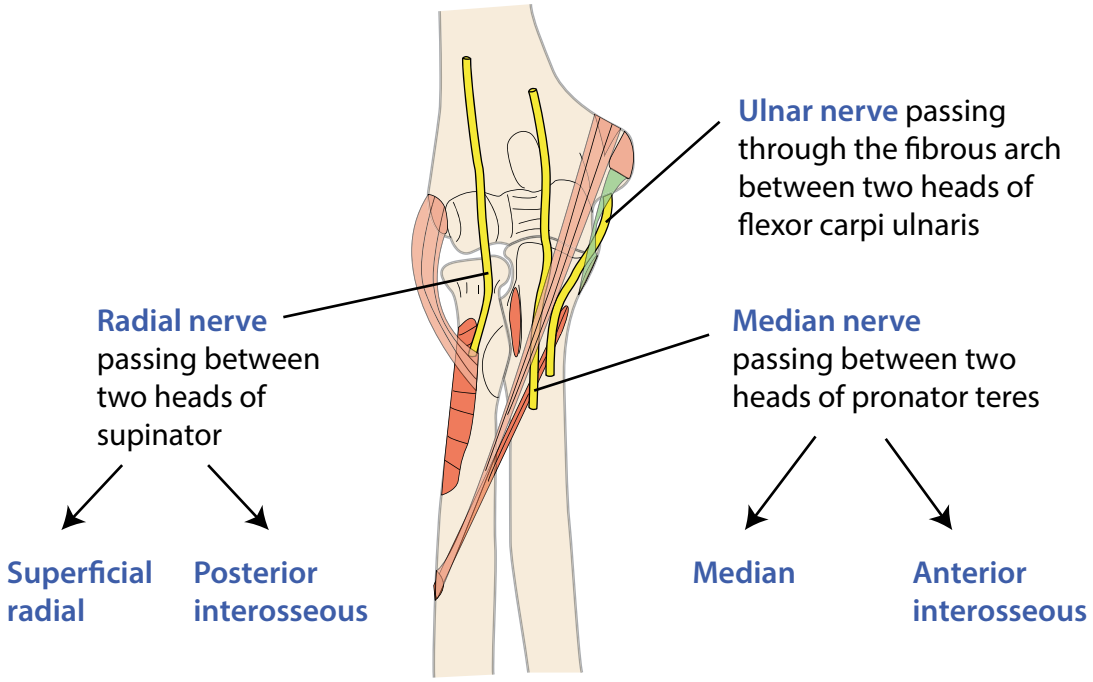
Action: Supinates. Best when arm is extended and biceps is not supinating

SUPINATOR

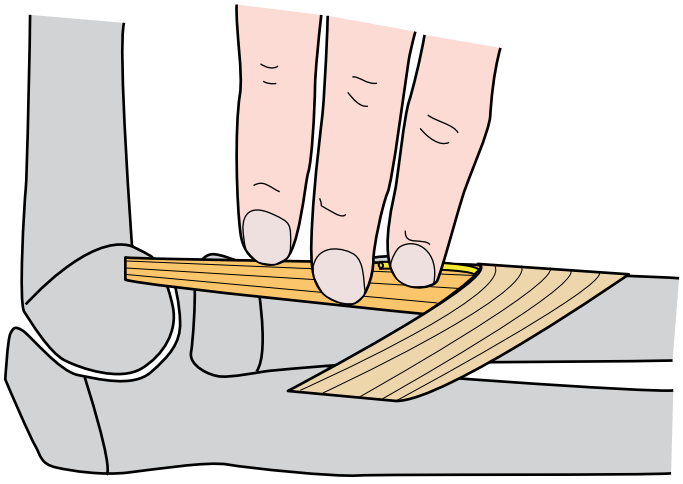
RELATIONSHIPS OF NERVES AND ARTERIES TO RIGHT PRONATOR TERES



NERVES PASSING BETWEEN TWO HEADS OF MUSCLES IN THE RIGHT ELBOW REGION

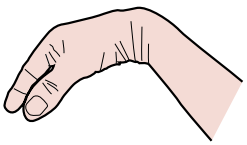


SURFACE ANATOMY OF POSTERIOR INTEROSSEOUS NERVE



Henry's method for finding the posterior interosseous nerve:
3 fingers inferior to head of radius as the nerve passes into supinator

4 CATEGORIES OF ACTION OF THE ANTERIOR FOREARM MUSCLES

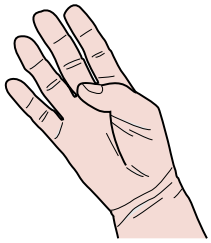


WRIST FLEXION

Flexor carpi ulnaris
Flexor carpi radialis

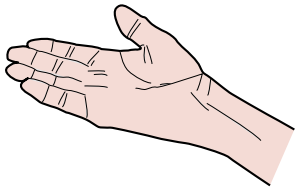
FINGER FLEXION

Flexor digitorum superficialis
Flexor digitorum profundus

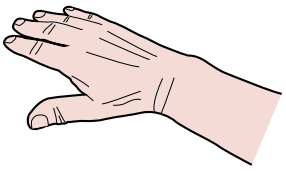


THUMB FLEXION

Flexor pollicis longus



FROM SUPINATION → TO PRONATION

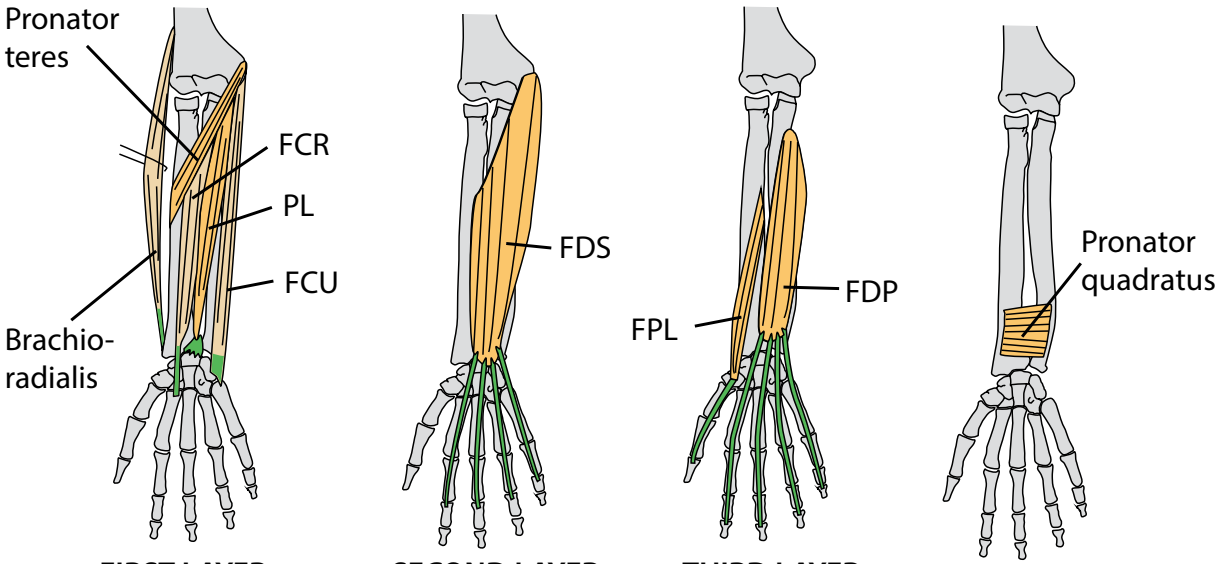


Pronator teres
Pronator quadratus

All supplied by MEDIAN nerve except FCU and 1/2 FDP - ULNAR nerve

Instead of learning a list of forearm muscles, it is best to consider the muscles that are needed to perform the movements shown above

RIGHT ANTERIOR FOREARM MUSCLES



FCR- Flexor carpi radialis
FCU- Flexor carpi ulnaris
FDP- Flexor digitorum profundus

FDS- Flexor digitorum superficialis
FPL- Flexor pollicis longus
PL- Palmaris longus

POSTERIOR ARM MUSCLES

TRICEPS

Origin: Long head -infraglenoid tubercle
Medial head - Medial spiral groove, posterior humerus, medial and lateral intermuscular septum
Lateral head - Superior/posterior humerus (linear)

Insertion: Long and lateral heads - flat tendon to posterior olecranon
Medial head - deep part of flat tendon and posterior capsule of elbow

Action: Extends elbow, weak extensor of shoulder. Long head stabilises the abducted shoulder

Nerve supply: Radial (C7,8)

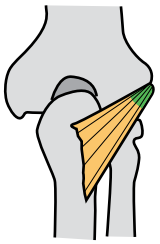
ANCONEUS

Origin: Lower lateral epicondyle

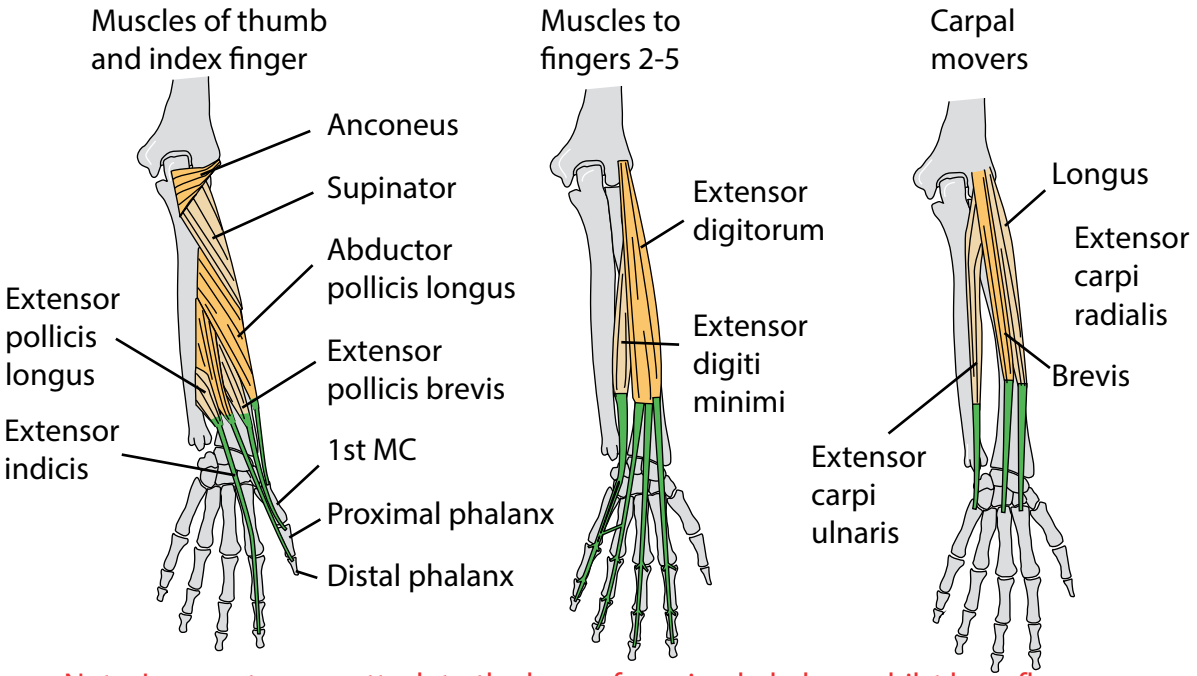
Insertion: Posterior/lateral ulna and olecranon

Action: Weak extensor. "Abducts" elbow in pronation

Nerve supply: Radial



MUSCLES OF POSTERIOR FOREARM

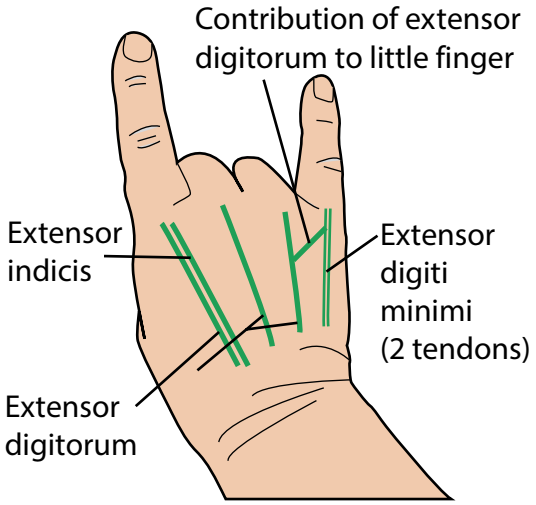


Note: Long extensors attach to the base of proximal phalanx whilst long flexors do not. On the flexor side it is the interossei and lumbricals that attach here and this accounts f

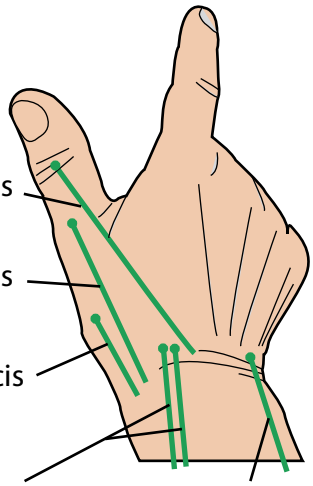
EXTENSOR COMPARTMENT MUSCLES

SUPINATION:
Supinator
(Biceps)

EXTENSION OF FINGERS



EXTENSION AND ABDUCTION OF THUMB



Extensor carpi radialis longus
Extensor carpi radialis brevis

Extensor carpi ulnaris

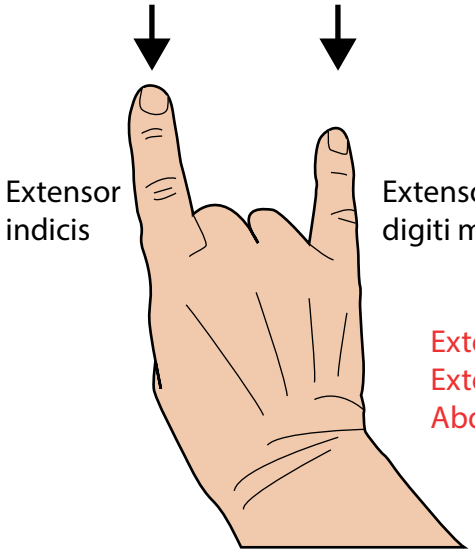
EXTENSION OF WRIST

Loss leads to ↓

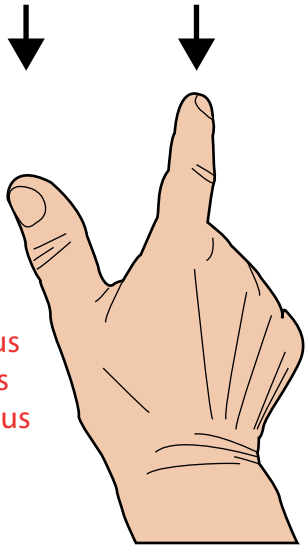
WRIST DROP!!

RULES FOR EXTENSOR TENDONS

In addition to tendons of extensor digitorum these two fingers have an extra tendon of their own



Four muscles arise deep in the posterior forearm and have tendons that pass to these two digits in the ratio of 3 to the thumb and 1 to the index finger

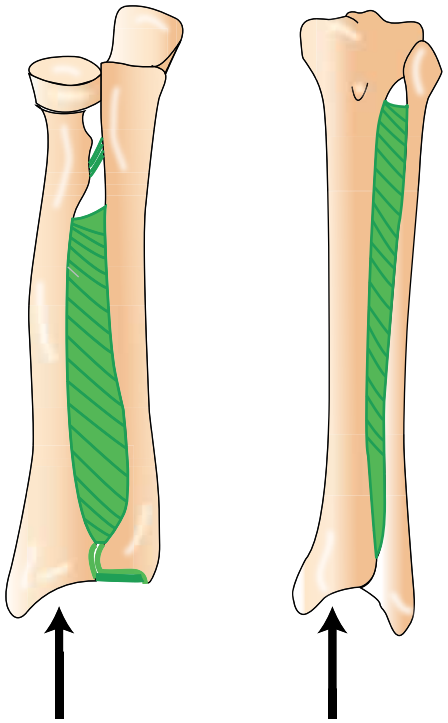


3

Extensor pollicis longus
Extensor pollicis brevis
Abductor pollicis longus

1

Extensor indicis



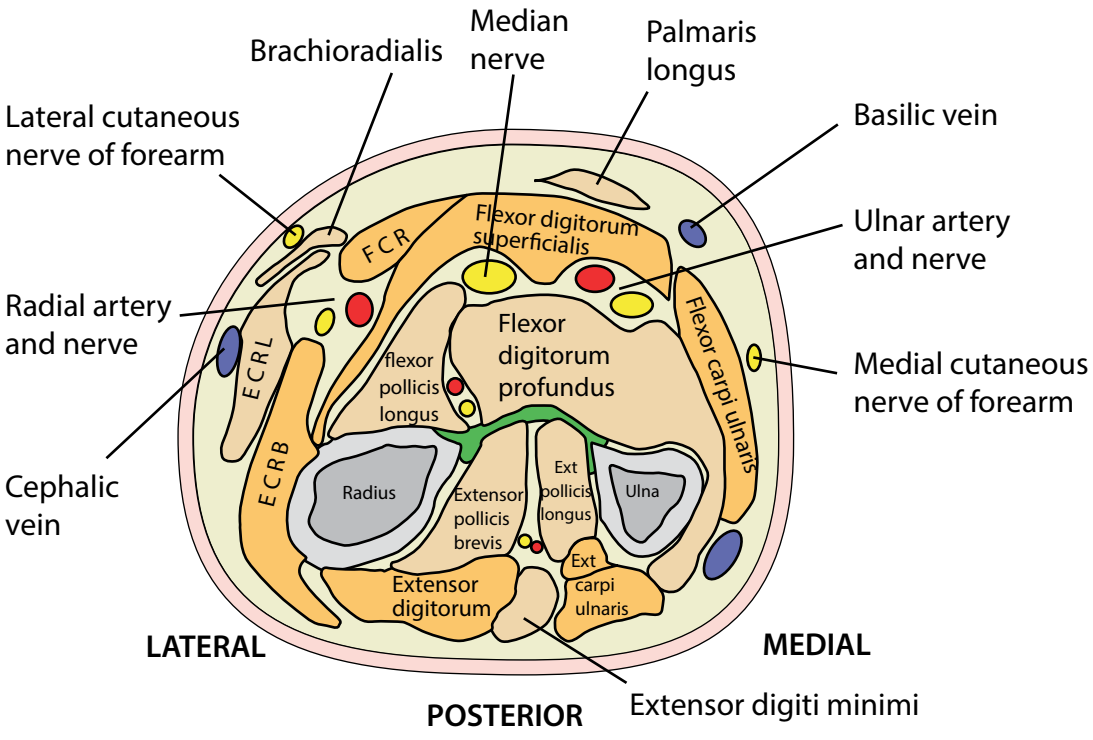
Right Radius and Ulna

Left Tibia and Fibula

INTEROSSEOUS MEMBRANES

Forces from the hand and foot are transmitted respectively to the radius and tibia. In order to share the impact of the force the interosseous membranes have fibres arranged so that the ulna and the fibula can share the the strain easily and immediately

CROSS SECTION OF RIGHT MID FOREARM LOOKING UP



RADIAL ARTERY

Starts: Midline in cubital fossa
On to: Supinator and tendon of pronator teres, flexor pollicis longus, insertion of pronator quadratus and lower radius
Lateral to: Flexor digitorum superficialis
Under: Flexor carpi radialis, brachioradialis and snuff box tendons
On: Trapezium
Between: Heads of 1st dorsal interosseus and heads of adductor pollicis
Medial to: Radial nerve in forearm and superficial branch of radial nerve
Branches: Dorsal and palmar carpal; superficial palmar branch (anastomoses with superficial palmar arch); arteria princeps pollicis to thumb; arteria radialis indicis to index finger; and finishes as deep palmar arch with its palmar metacarpal branches

ULNAR ARTERY

Starts: Midline in cubital fossa
Passes deep to: Both heads of pronator teres and fibrous arch of flexor digitorum superficialis
On: Flexor digitorum profundus
Lateral to: Ulnar nerve
Superficial to: Flexor retinaculum
Ends as: Superficial palmar arch with its palmar digital branches and a branch to the deep arch
Branches: Common interosseous giving anterior and posterior branches

Anterior interosseous
Between: Flexor digitorum profundus and flexor pollicis longus
Supplies: Deep flexor muscles and bones
Passes: Posteriorly in lower forearm through interosseous membrane to supplement posterior interosseous artery
Ends as: Dorsal carpal anastomosis

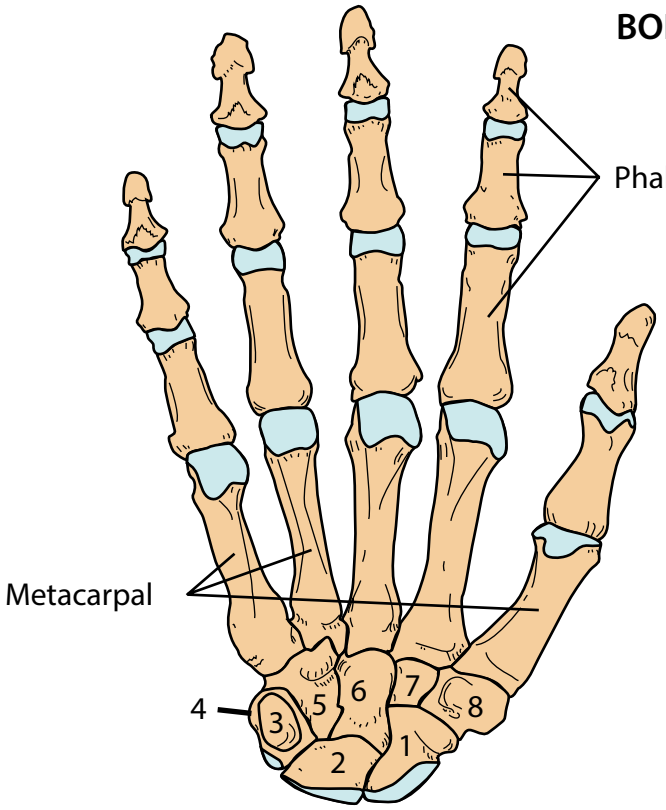
Posterior interosseous
Passes: Into posterior compartment of forearm above the interosseous membrane
Supplies: Muscles of posterior forearm
Ends by: Anastomosing with anterior interosseous artery

1.5 Wrist and Hand

USE OF HAND

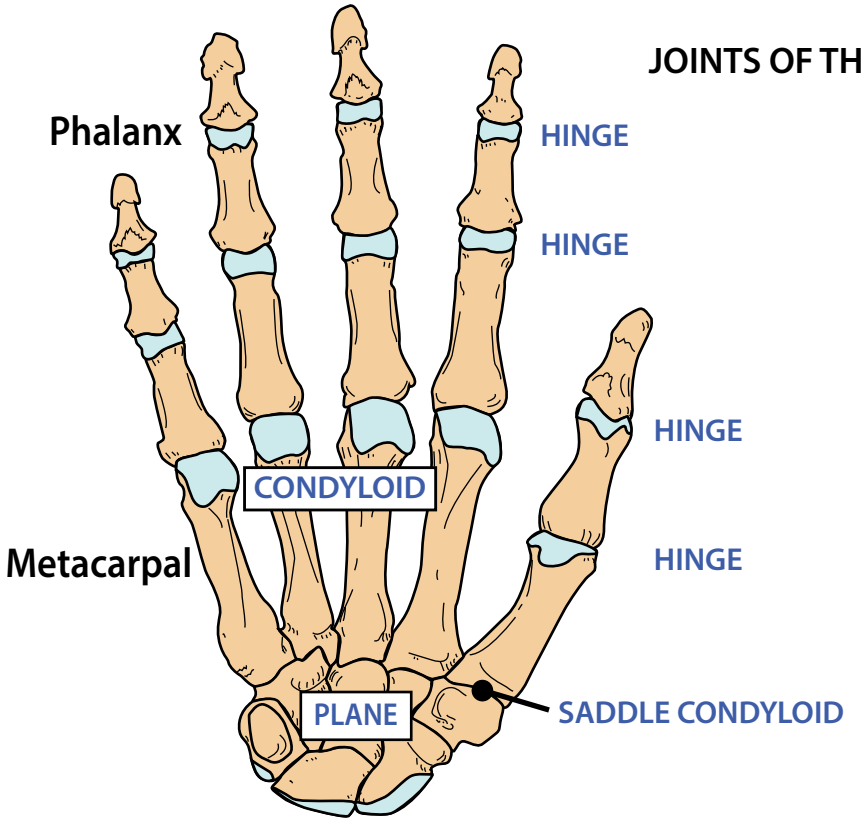
Grip
Percussion
Aggression/defence
Sensory
Expression

BONES OF THE HAND

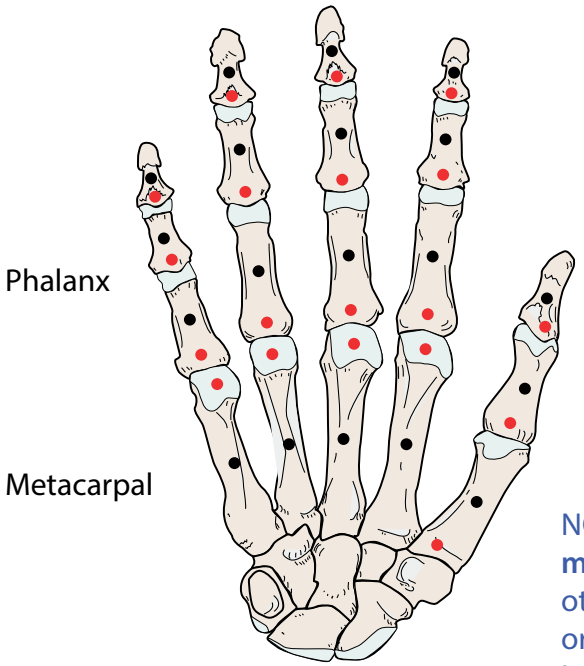


1. Scaphoid
2. Lunate
3. Pisiform
4. Triquetral
5. Hamate
6. Capitate
7. Trapezoid
8. Trapezium

JOINTS OF THE HAND



METACARPAL & PHALANGEAL OSSIFICATION

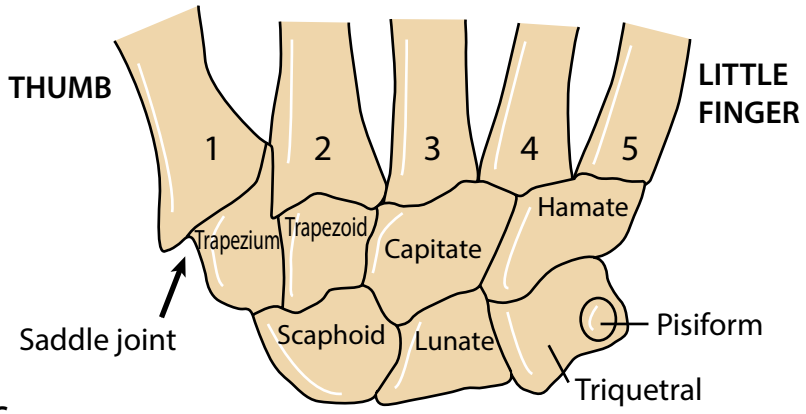


- **Primary centres**
  Appear 9th intrauterine week of life, mid shaft.

- **Secondary centres**
  Appear 2-3 years after birth. All unite 18-20 years.

NOTE: **The secondary centre for the 1st metacarpal** is proximal whilst in all the other metacarpals it is distal. Could it originally have been a phalanx?
It is the same in the foot.

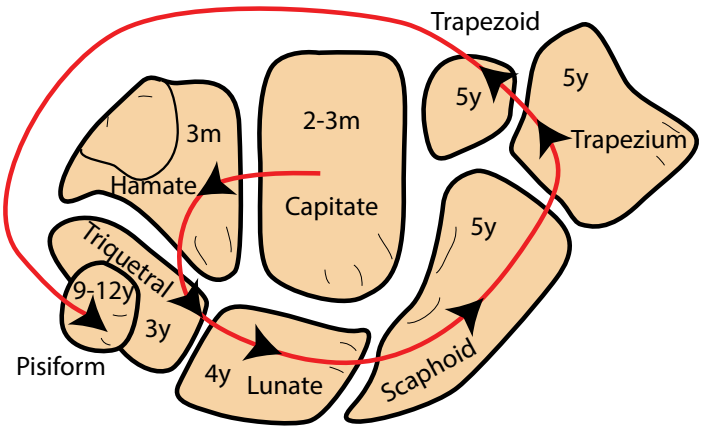
CARPAL BONES AND JOINTS



JOINTS

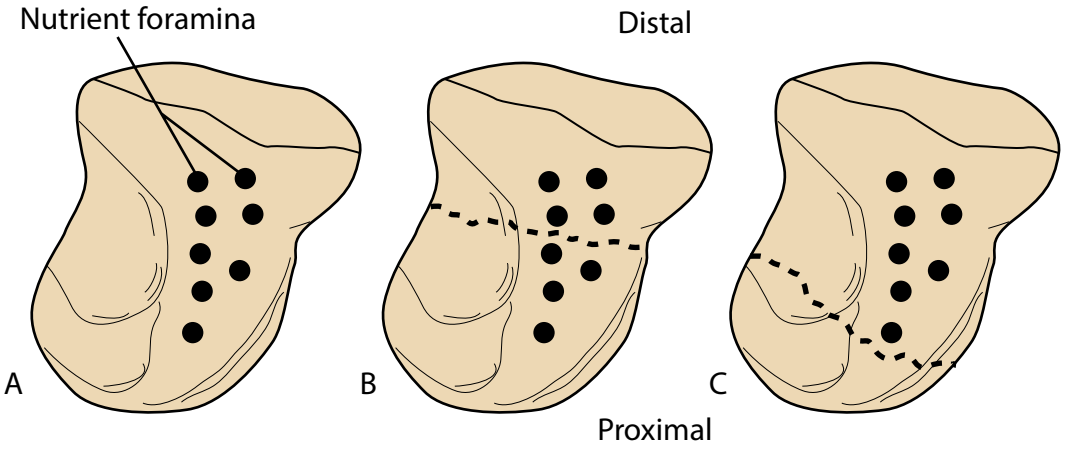
1. Between 1st metacarpal and trapezium there is a saddle condyloid joint that allows flexion, extension, adduction, abduction and rotation. The rotation is not free and depends on the degree of opposition (i.e. it is "controlled").
2. All the other joints in the carpus are plane joints.
3. The carpometacarpal joints become progressively more mobile from thumb to little finger so that grip is more stable towards index finger and thumb.

OSSIFICATION OF BONES OF THE RIGHT HAND



The red line with arrows indicates the order in which the **primary centres** appear from birth onwards. Anticlockwise in the right hand looking from the anterior surface

BLOOD SUPPLY OF THE SCAPHOID



Blood vessels usually enter the bone distally with few or no nutrient foramina in the proximal segment. Avascular necrosis is less likely with a waist fracture (B) but very likely with a proximal fracture (C).

NOTE: The lunate may be dislocated ventrally either in association with a fracture of the scaphoid or separately. It may damage the median nerve by pushing it against the flexor retinaculum.

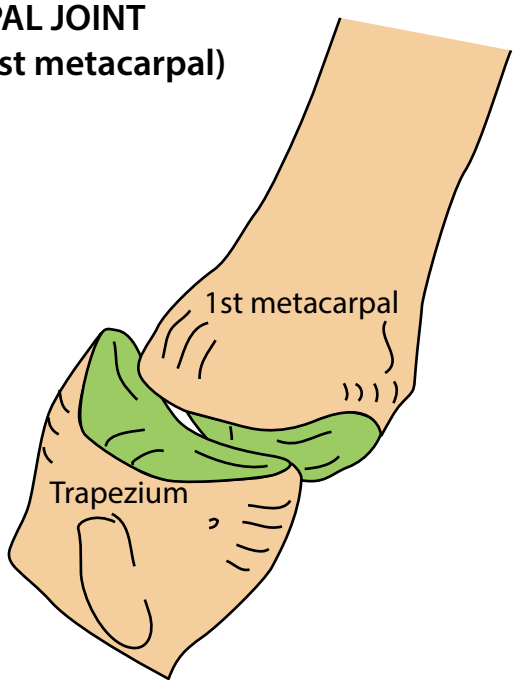
1st CARPOMETACARPAL JOINT (Between trapezium and 1st metacarpal)

SADDLE CONDYLOID

Allows:

- Flexion
- Extension
- Adduction
- Abduction
- Circumduction
- "Controlled rotation"

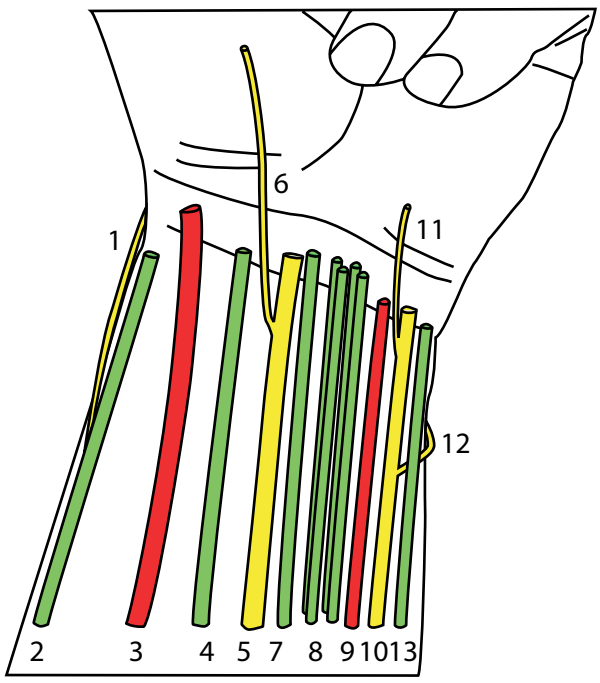
All together = Opposition



WRIST JOINT

Synovial. Strong+
Proximal: Radius and fibrocartilage
Distal: Scaphoid, lunate (triquetral in extreme adduction)
Triangular cartilage: Holds radius and ulna together and separates radiocarpal joint from inferior radio-ulnar joint
Capsular ligaments: Thick collateral at sides
Palmar radiocarpal ligaments: Radius to lunate and capitate
Movements: Flexion 80° (Mostly midcarpal)
Extension 60° (Mostly wrist)
Abduction 15°
Adduction 60°

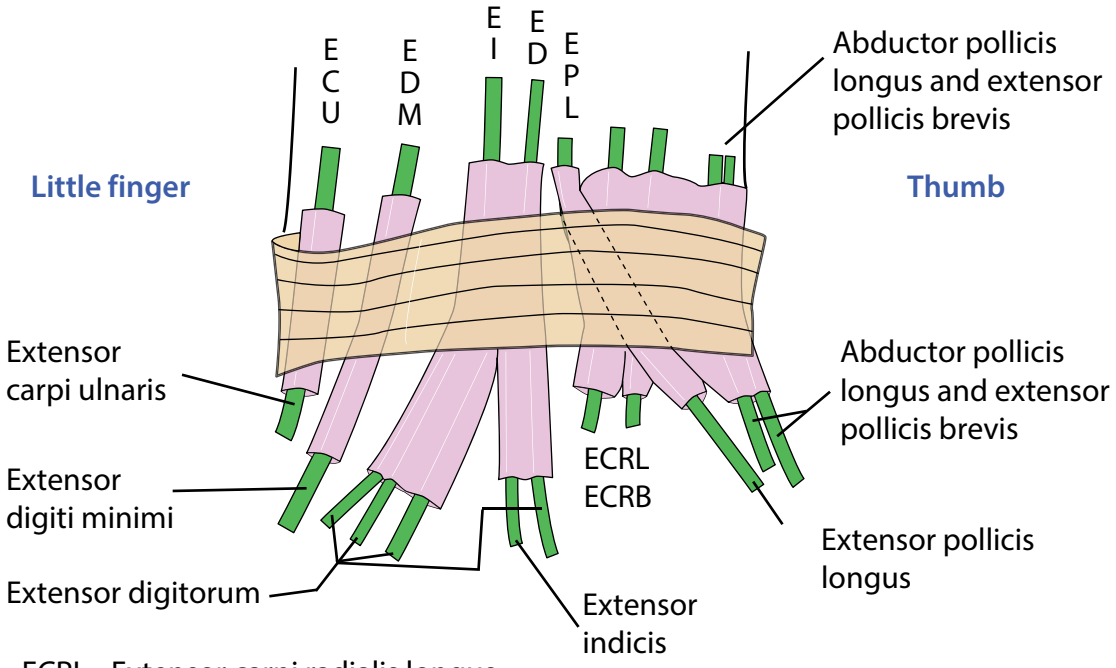
VENTRAL ASPECT OF LEFT WRIST



Structures from radial to ulnar side:

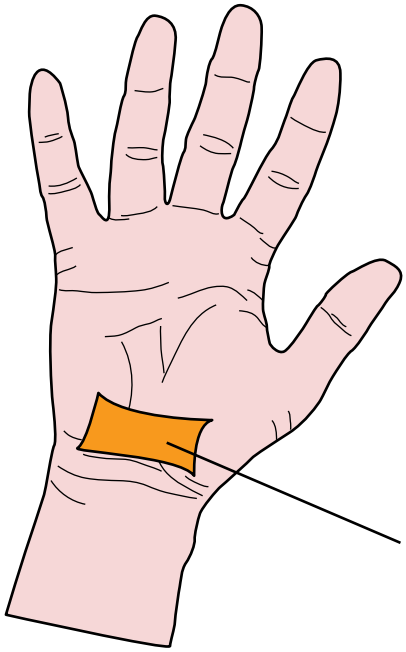
1 Superficial branch of the radial nerve (emerging posterior to brachioradialis)
2 Brachioradialis
3 Radial artery
4 Flexor carpi radialis
5 Median nerve with its palmar cutaneous branch (6)
7 Palmaris longus
8 Flexor digitorum superficialis (4 tendons)
9 Ulnar artery
10 Ulnar nerve with its palmar cutaneous branch (11) and dorsal cutaneous branch (12)
13 Flexor carpi ulnaris

RIGHT EXTENSOR RETINACULUM



ECRL - Extensor carpi radialis longus
ECRB - Extensor carpi radialis brevis

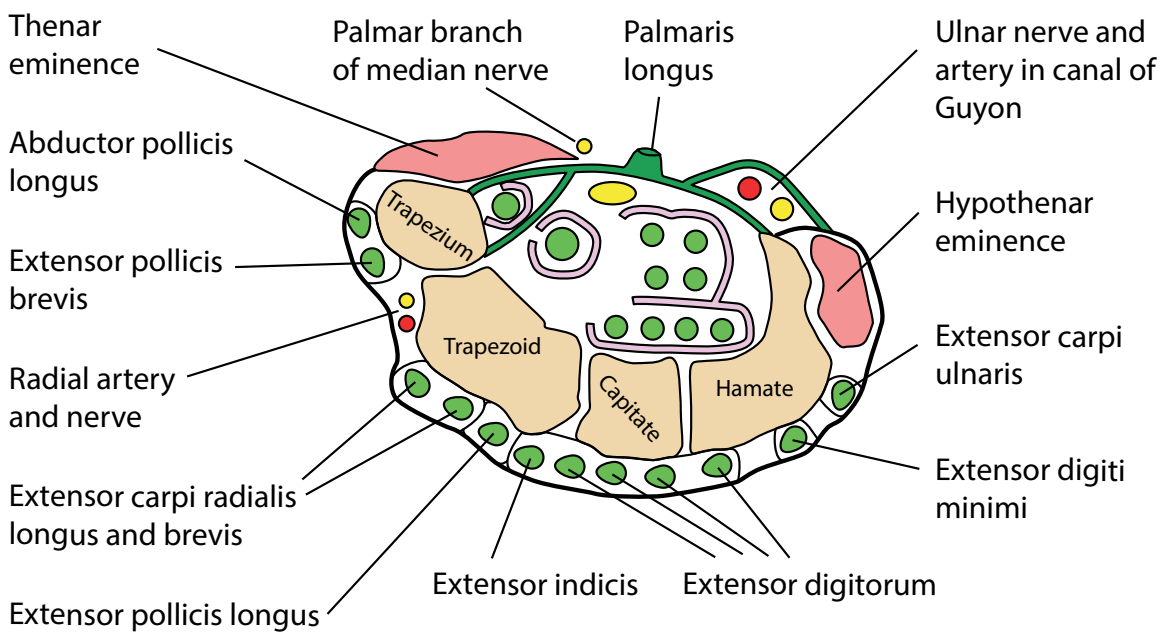
FLEXOR RETINACULUM



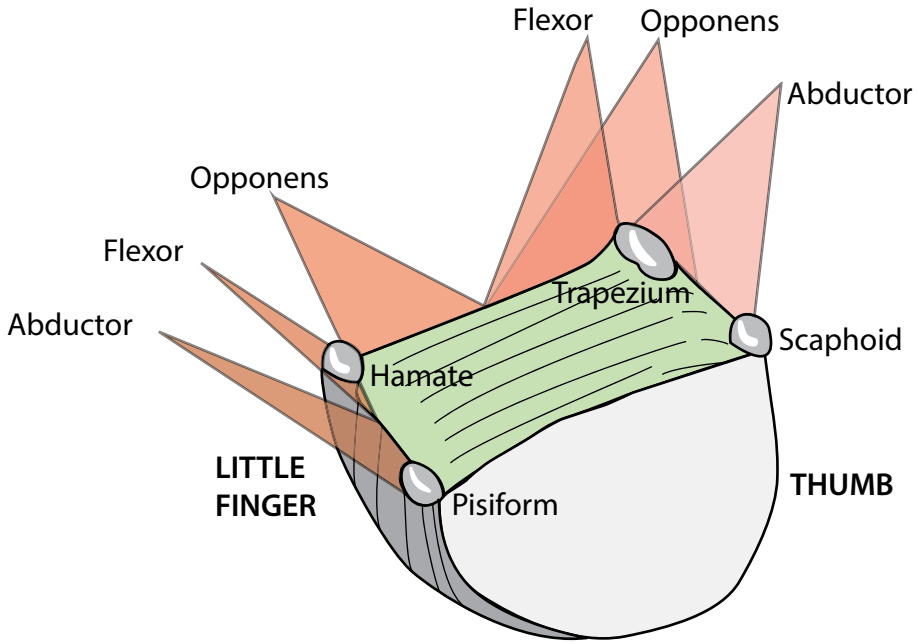
Arises: Tubercle of scaphoid and ridge of trapezium
Inserts: Pisiform and hook of hamate
Inserting into it: Palmaris longus and brevis
Arising from it: Thenar and hypothenar muscles
Superficial to it: Ulnar nerve and artery, palmar cutaneous branches of median and ulnar nerves
Deep to it: Contents of carpal tunnel and flexor carpi radialis in a separate compartment

Position of flexor retinaculum in hand. Proximal edge is level with distal wrist crease.

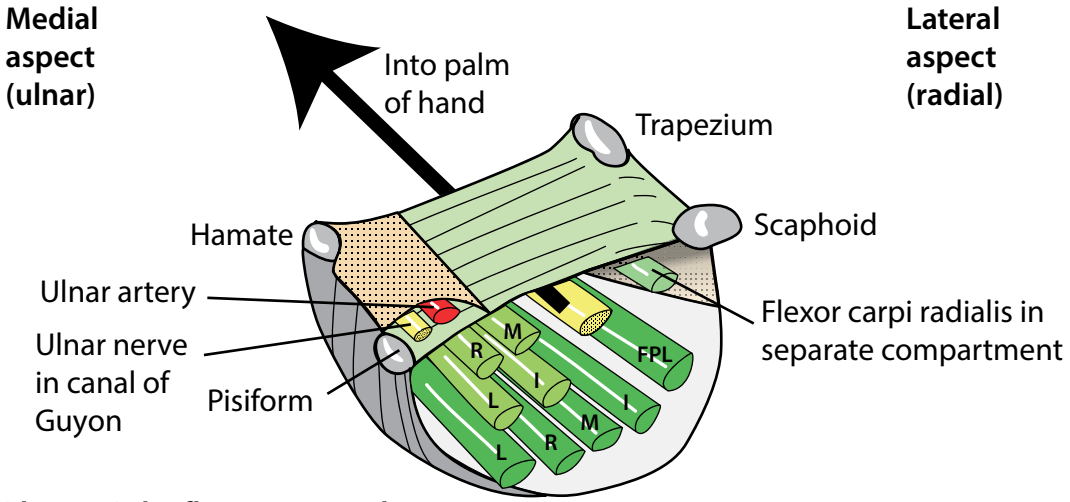
FLEXOR RETINACULUM



MUSCLE ATTACHMENTS TO FLEXOR RETINACULUM



FLEXOR RETINACULUM AND CARPAL TUNNEL



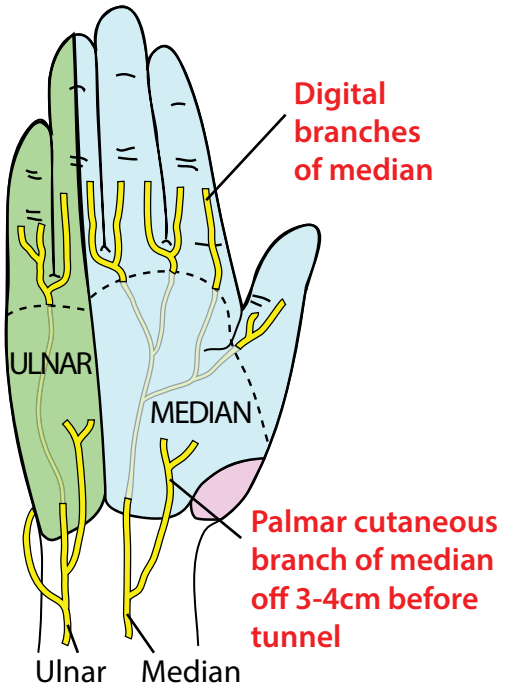
Beneath (deep to) the flexor retinaculum

1. Median nerve
2. 4 tendons of flexor digitorum profundus
3. 4 tendons of flexor digitorum superficialis
4. Tendon of flexor pollicis longus
5. Flexor carpi radialis (in its own compartment)

Superficial to the flexor retinaculum

1. Ulnar nerve and ulnar artery (in their own tunnel (Canal of Guyon)
2. Palmar cutaneous branch of median nerve

CARPAL TUNNEL SYNDROME



1. **Pain and paraesthesia** in lateral fingers and thumb, worse at night and waking patient.

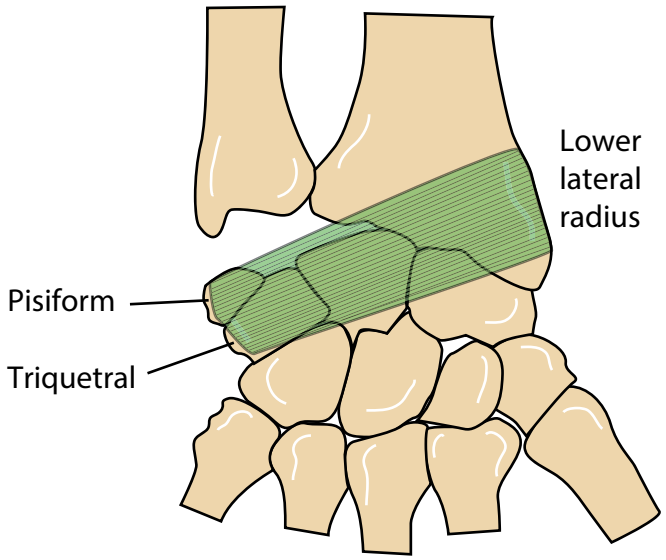
2. **Sensory loss** similar distribution EXCEPT skin over thenar eminence spared (palmar cutaneous branch arising before carpal tunnel).

3. **Weakness** of abductor pollicis brevis.

4. **Associated with** hypothyroidism, pregnancy, arthritis, tenosynovitis, inflammation, old fractures but often idiopathic.

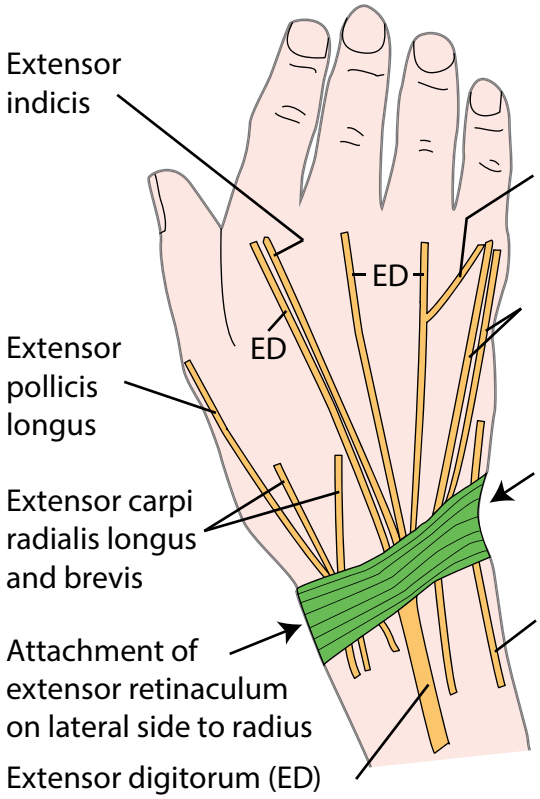
5. **Tinel's Test:** Tapping over flexor retinaculum gives tingling.

RIGHT EXTENSOR RETINACULUM
Attachments



2.5cm wide, oblique, ribbon-like band
Attached from radial styloid to pisiform and triquetral (NOT ulna)
Fibrous septa to give 6 compartments

EXTENSOR RETINACULUM OF WRIST



Extensor digitorum to little finger

Two tendons of extensor digiti minimi

Attachment of extensor retinaculum on medial side to pisiform and triquetral

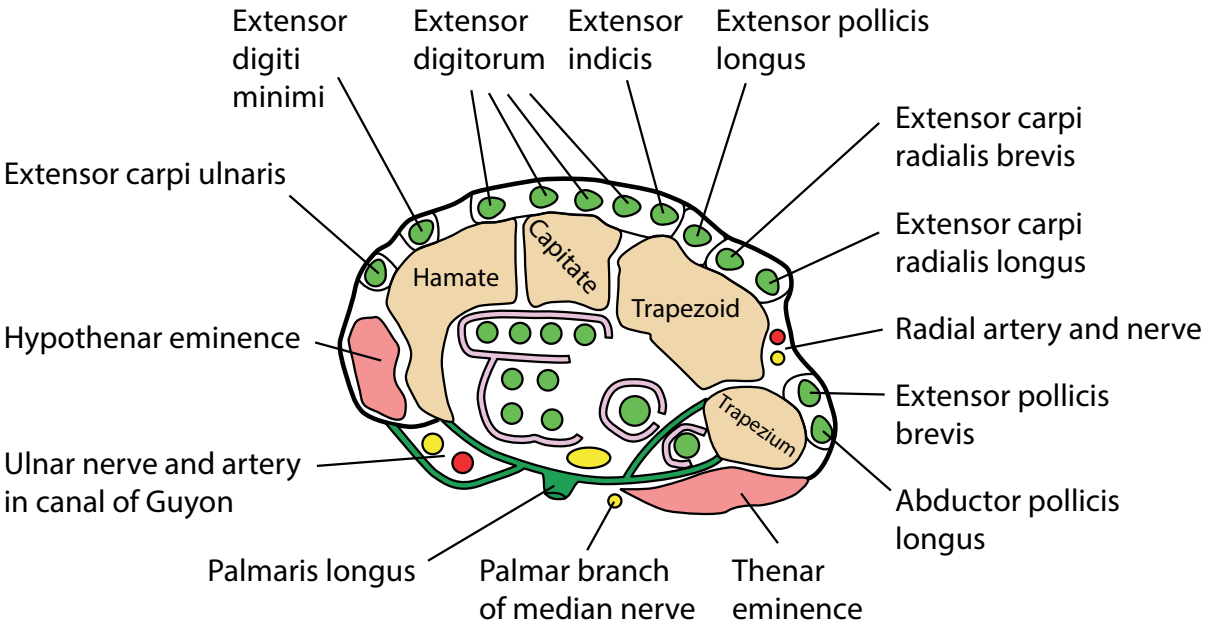
Extensor carpi ulnaris

Note:
1. The extensor retinaculum does NOT attach to the ulna otherwise it would change in length with pronation and supination.

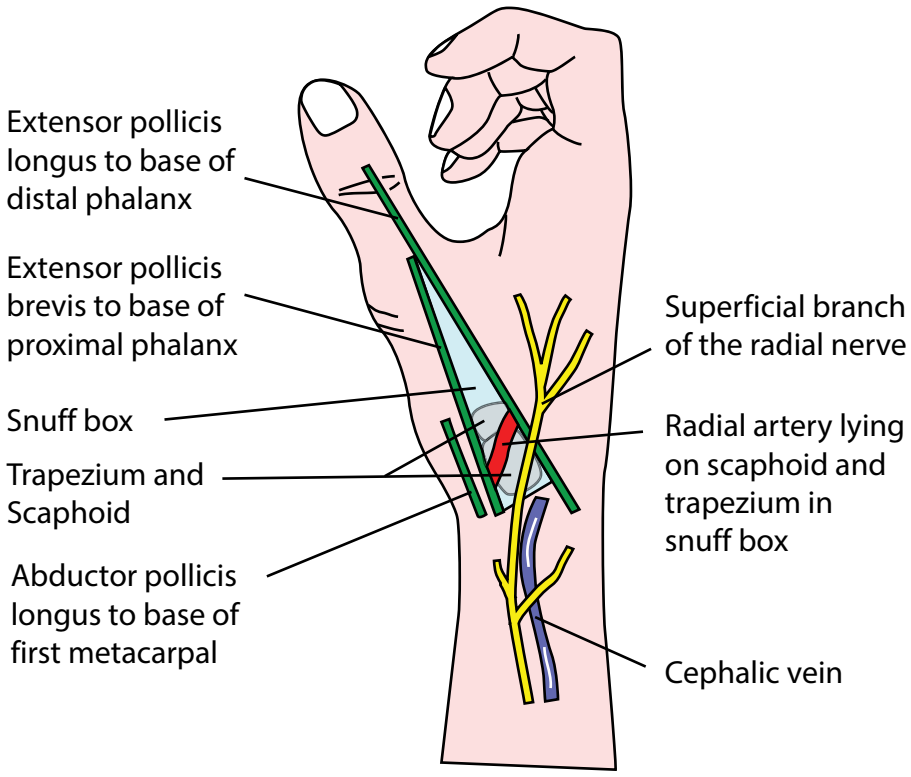
2. The extensor digitorum tendon to the little finger leaves the tendon to the ring finger.

EXTENSOR TENDON COMPARTMENTS JUST BEYOND THE LEFT EXTENSOR RETINACULUM

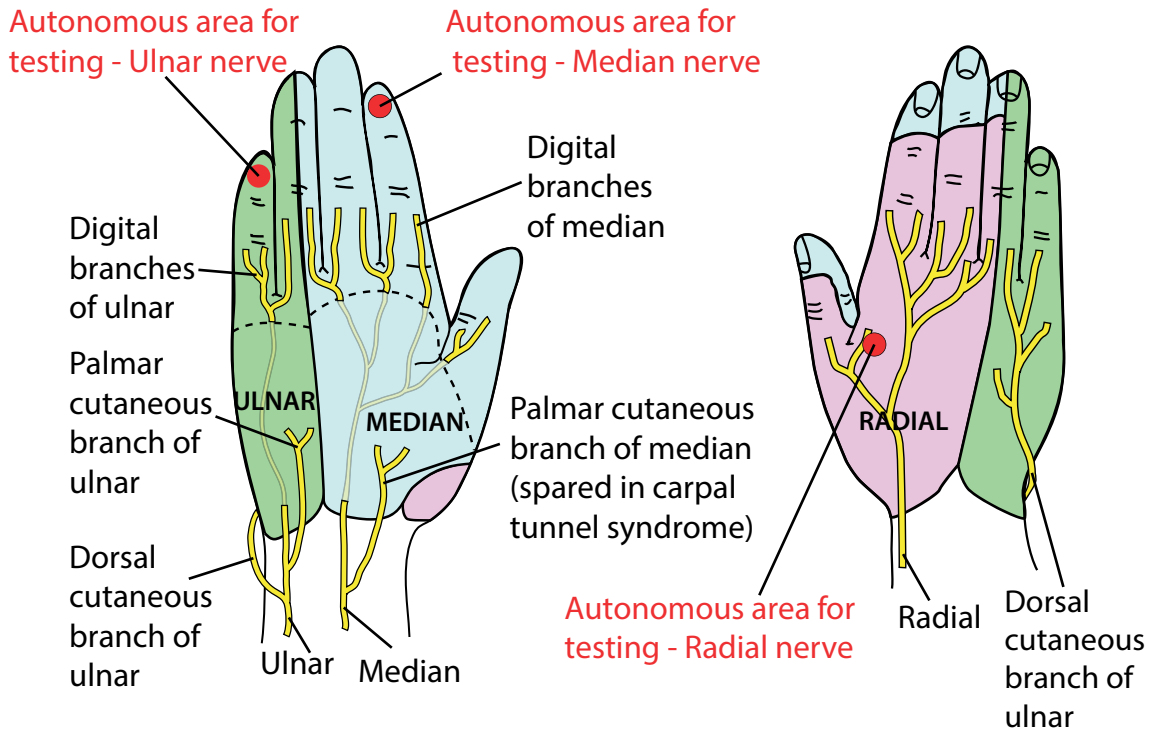
LITTLE FINGER THUMB



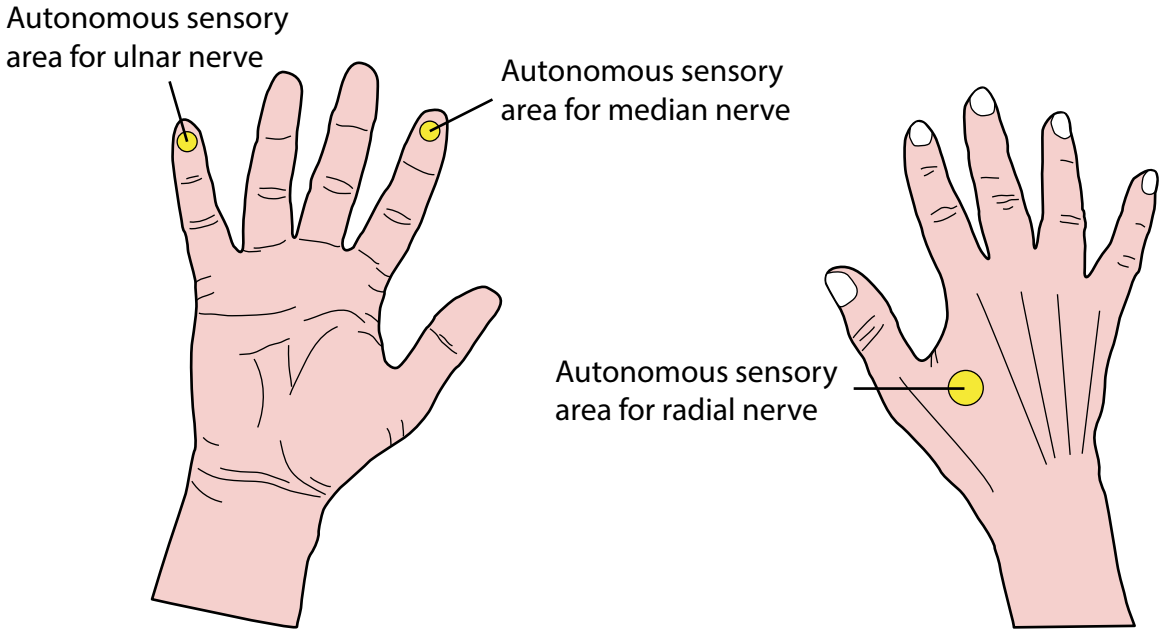
ANATOMICAL SNUFF BOX



CUTANEOUS NERVE SUPPLY OF HAND

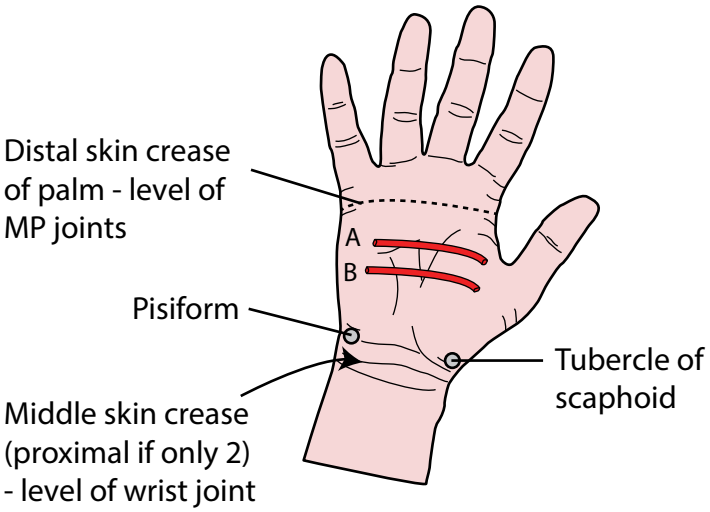


AUTONOMOUS SENSORY AREAS IN RIGHT HAND



An autonomous sensory area is that part of a dermatome that has no overlap from adjacent nerves. Thus it is used to test the integrity of the nerve supplying that distribution

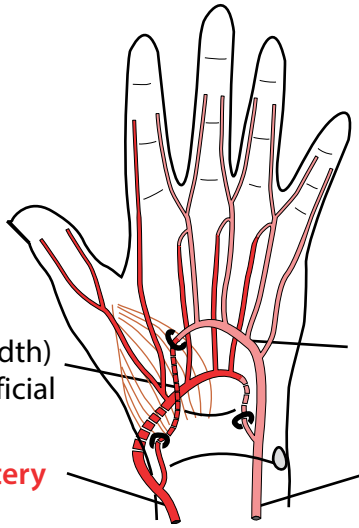
PALMAR ARTERIAL ARCHES



A **Superficial palmar arch**
Level with base of outstretched thumb.
From ulnar artery.
1/2 way between distal palmar crease and distal wrist crease

B **Deep palmar arch**
From radial artery.
1cm proximal to superficial arch

PALMAR ARTERIAL ARCHES (left hand)



Allen's Test: Provides information as to which arch is dominant

Deep palmar arch
1cm (finger's breadth) proximal to superficial arch

Superficial palmar arch
at level of base of outstretched thumb

Radial artery

Ulnar artery

DEEP PALMAR ARCH
From radial artery. Communicates with superficial arch
Branches:
- Princeps pollicis
- Radialis indicis
- 3 palmar metacarpal
- 3 perforating branches

SUPERFICIAL PALMAR ARCH
From ulnar artery.
Communicates with deep arch
Branches:
- Palmar digital arteries and communicating branches with metacarpal arteries of deep arch

PALMAR APONEUROSIS AND PALMAR BREVIS

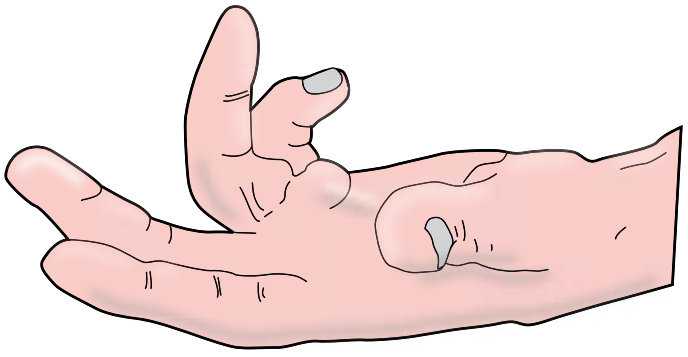
Palmar aponeurosis

- Extension of palmaris longus via flexor retinaculum
- Central area is strong, thick and triangular
- **Inserts:** into deep transverse ligament of palm and fibrous flexor sheaths
- **Action:** ties skin of palm and fingers down

Palmaris brevis

- **Origin:** Flexor retinaculum and medial border of proximal palmar aponeurosis
- **Insertion:** Dermis of ulnar side of hand
- **Action:** Wrinkles skin
- **Nerve supply:** Superficial branch of ulnar nerve

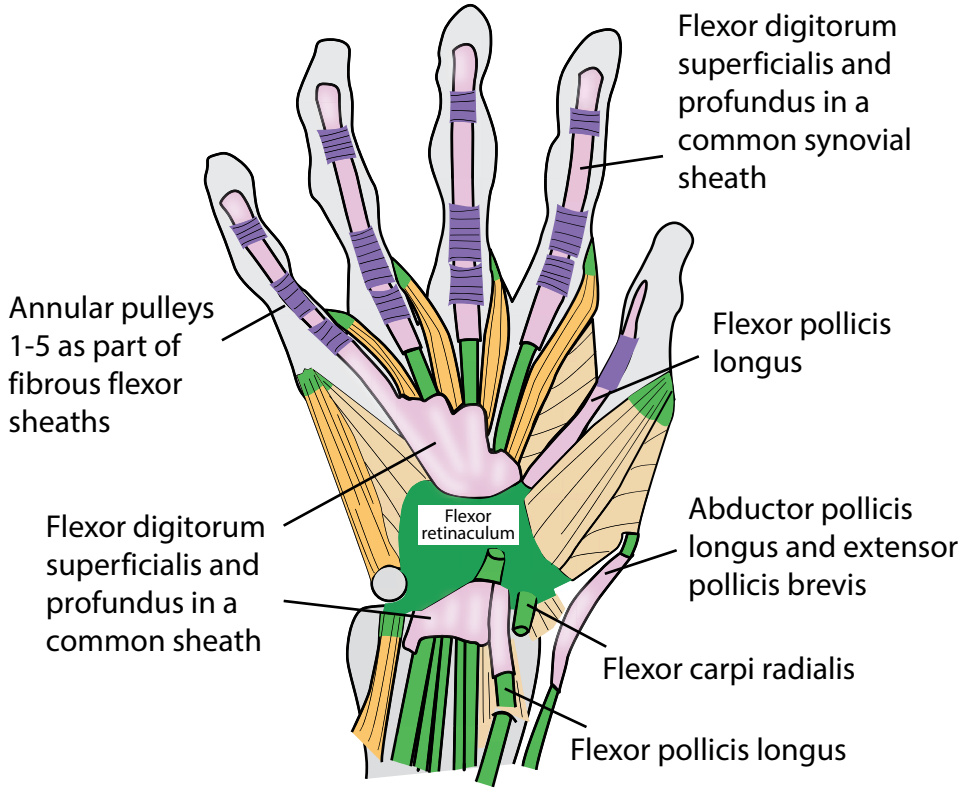
DUPUYTREN'S CONTRACTURE



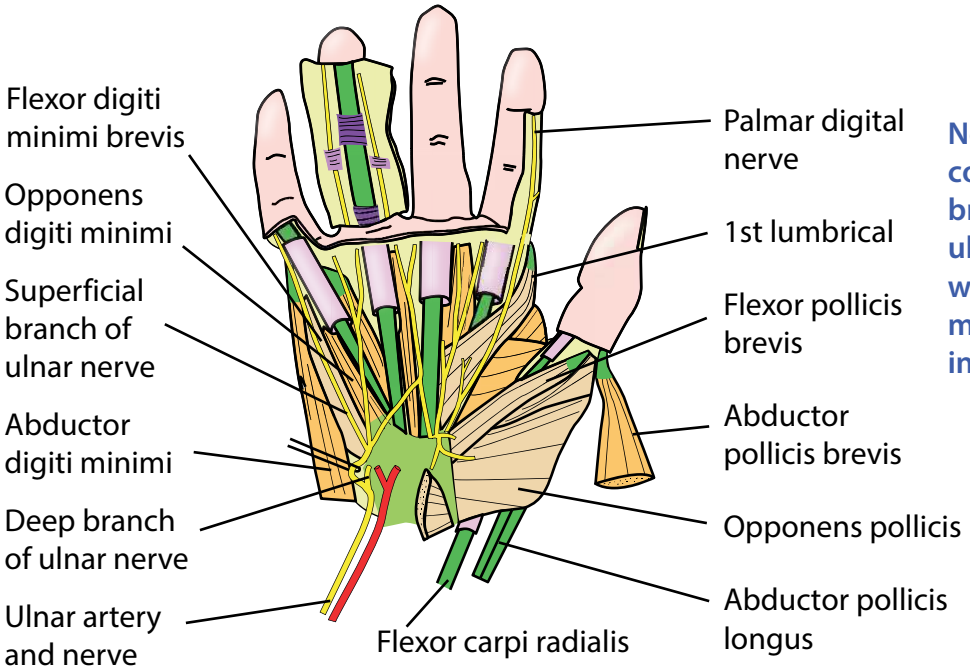
Typical appearances with maximal deformity of ring and little fingers due to fibrosis and shortening of palmar aponeurosis

During surgery for this condition, great care must be taken to avoid damage to the recurrent (muscular) branch of the median nerve which supplies the muscles of the thenar eminence

SYNOVIAL SHEATHS IN PALM OF HAND

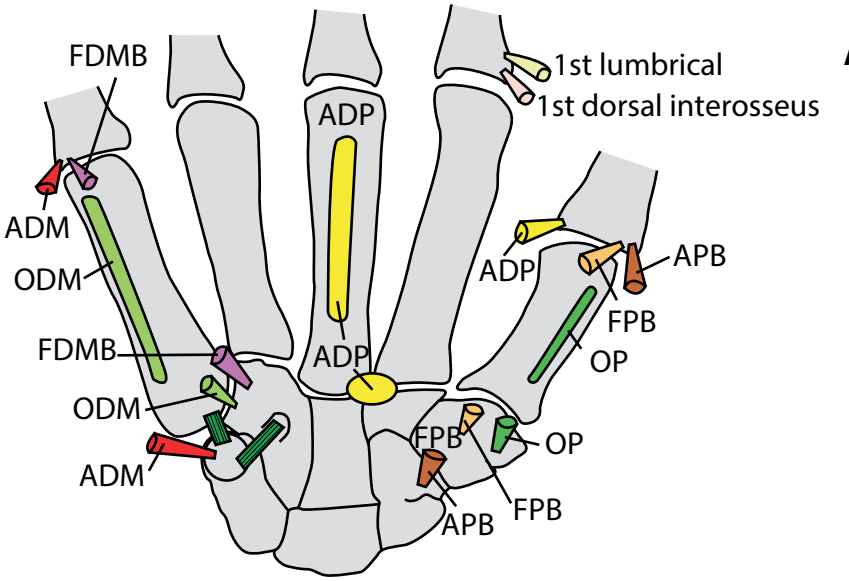


DISSECTION OF PALM TO SHOW NERVES AND THENAR AND HYPOTHENAR MUSCLES



Note the communicating branch of the ulnar nerve with the median nerve in the palm

ATTACHMENTS OF SMALL MUSCLES OF THE HAND



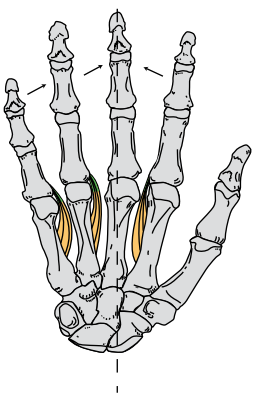
Adductor pollicis
Opponens digiti minimi
Flexor digiti minimi brevis
Pisometacarpal and Pisohamate ligaments
Opponens pollicis
Abductor pollicis brevis
Abductor digiti minimi
Flexor pollicis brevis

INTEROSSEOUS MUSCLES

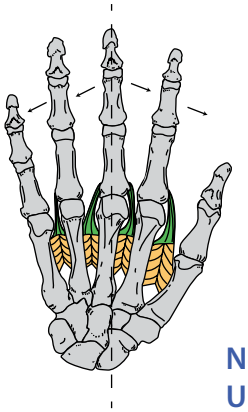
Origin: Anterior shafts of metacarpals 2,4,5
Insertion: Dorsal expansion and proximal phalanx
Action: Flex metacarpophalangeal and extend both interphalangeal joints. Adduct as per arrows

Origin: Inner shafts all metacarpals
Insertion: Dorsal expansion and proximal phalanx
Action: Flex metacarpophalangeal and extend both interphalangeal joints. Abduct as per arrows

PALMAR (PAD)
3



UNIPENNATE

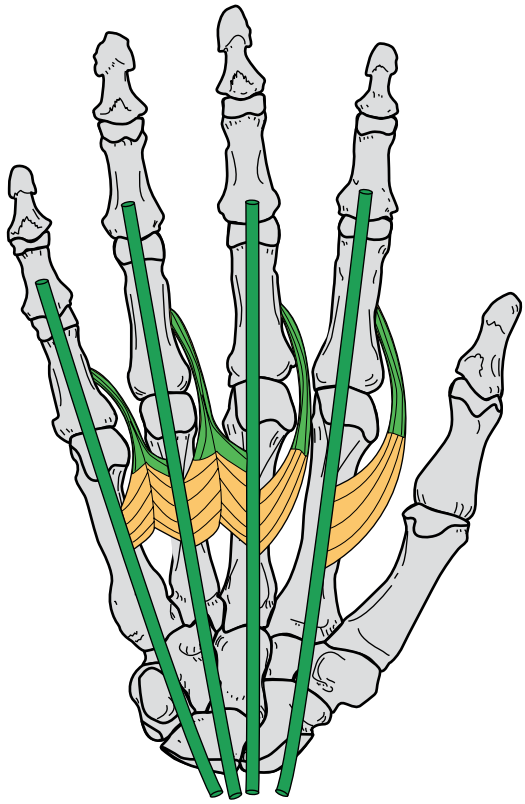


BIPENNATE

DORSAL (DAB)
4

Nerve supply: Ulnar nerve

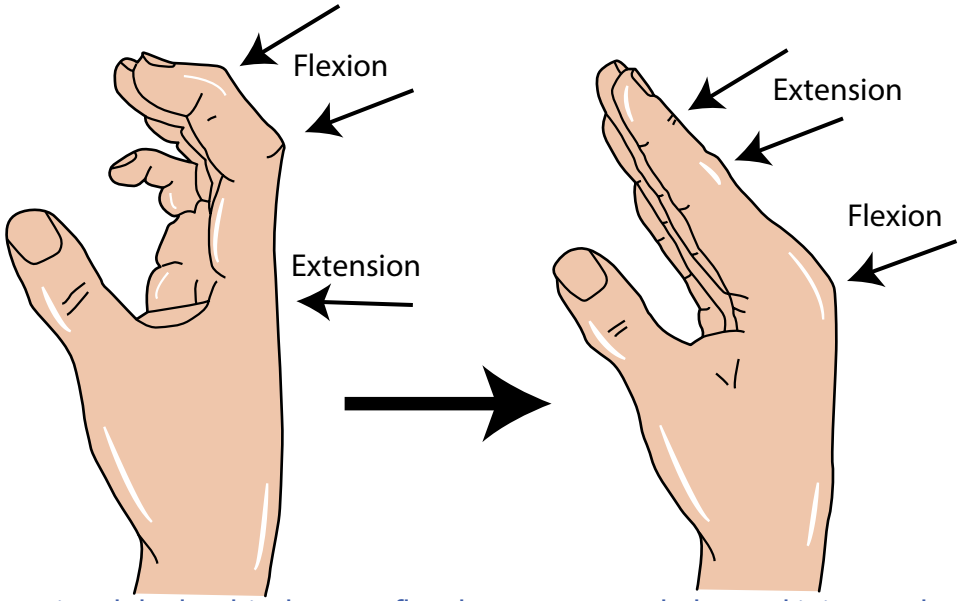
They act by taking up the slack in the extensor expansion so that the pull of



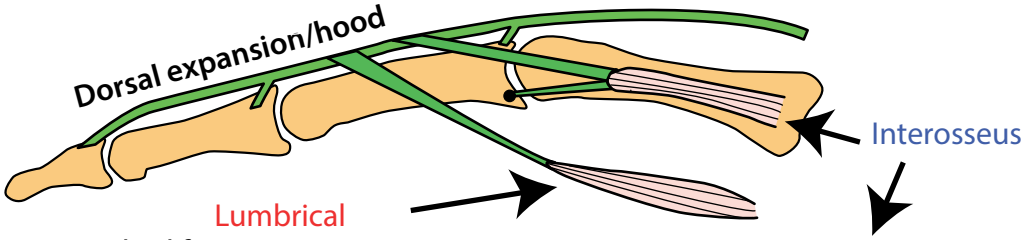
RIGHT LUMBRICALS

Origin: 4 tendons from flexor digitorum profundus, radial 2 are unipennate, ulnar 2 bipennate
Insertion: Extensor expansion over dorsum of proximal phalanx, distal to insertion of interossei, on radial side of fingers 2-5. NO bony attachments
Action: Flexion of metacarpophalangeal joints and extension of both interphalangeal joints of all fingers
Nerve supply: Ulnar nerve to ulnar 2, median nerve to radial 2 (can be 2:2, 3:1 or 1:3)

ACTION OF THE INTEROSSEI AND LUMBRICALS



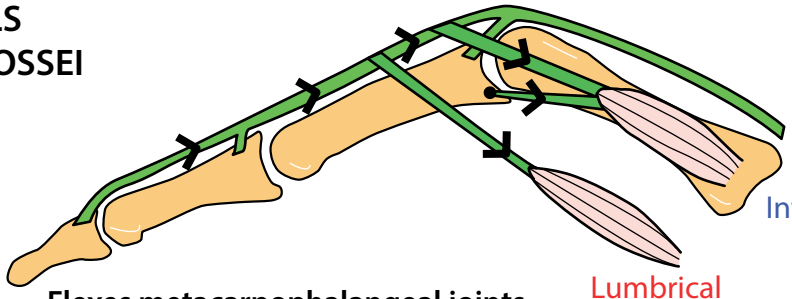
Both the interossei and the lumbicals act to flex the metacarpophalangeal joints and extend the two interphalangeal joints. Thus, if this action is disabled the hand is clawed (left hand image) due to the action of extensor digitorum on the metacarpophalangeal and the action of flexor digitorum profundus on the two interphalangeal joints. In addition, the interossei adduct and abduct the fingers but this is secondar



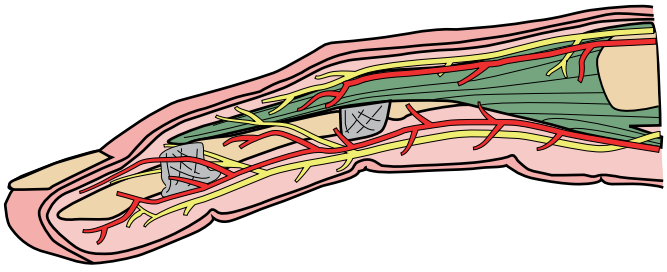
Attached from **tendon** (flexor digitorum profundus) to **tendon** (dorsal expansion)

Attached to **bone** (base of proximal phalanx) AND **tendon** (dorsal expansion)

ACTION OF LUMBRICALS AND INTEROSSEI

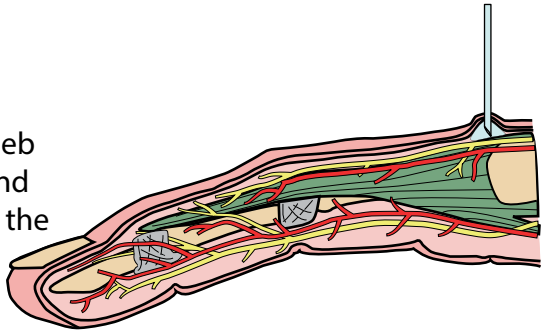


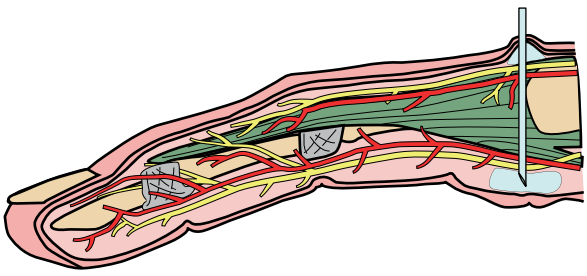
Flexes metacarpophalangeal joints
Extends interphalangeal joints



ANATOMY OF A RING BLOCK

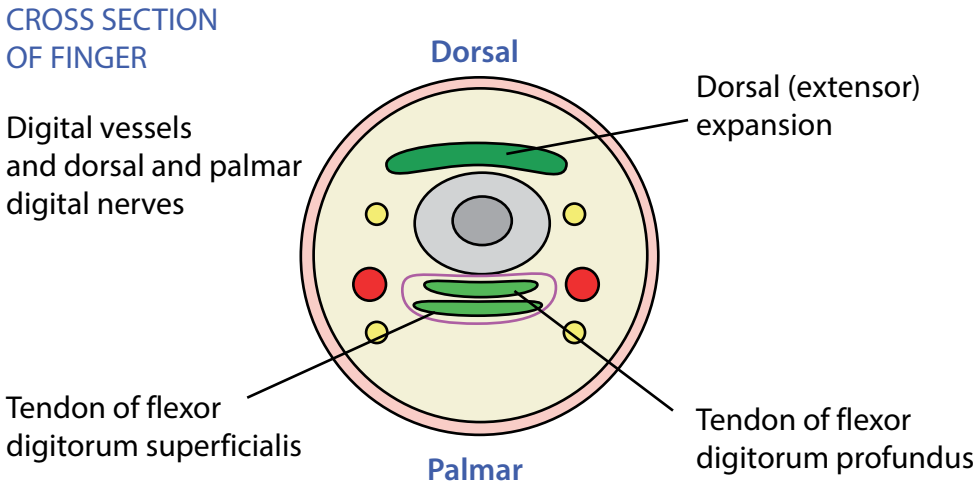
1. The dorsal branches are first infiltrated starting with a single bleb of local anaesthetic on one side and then passing the needle across to the opposite side subcutaneously



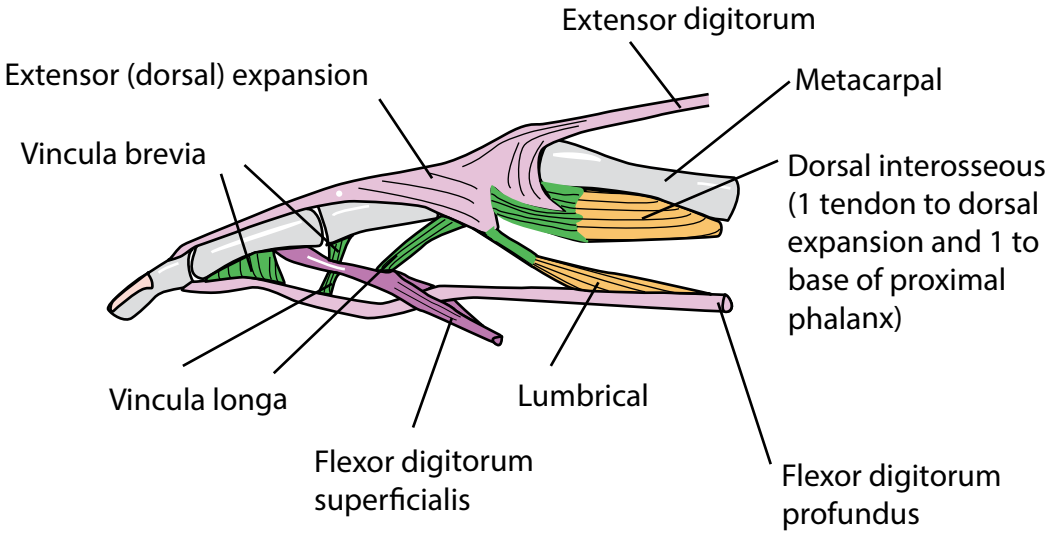


2. The needle is then advanced to infiltrate the ventral branches through the numb areas on each dorsal aspect

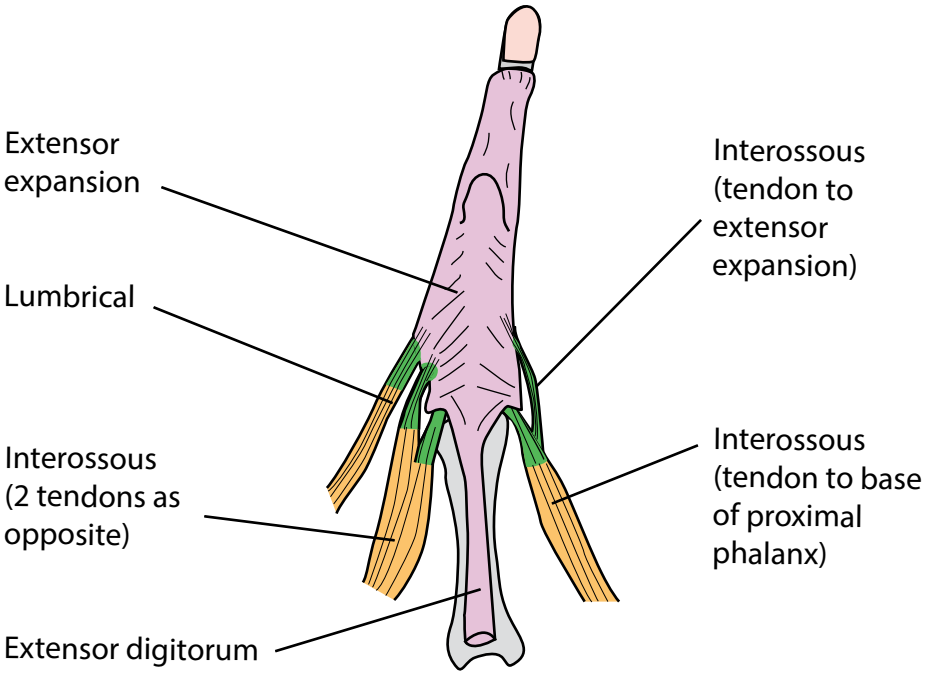
FINGER TO SHOW TENDONS AND DIGITAL NERVES AND ARTERIES



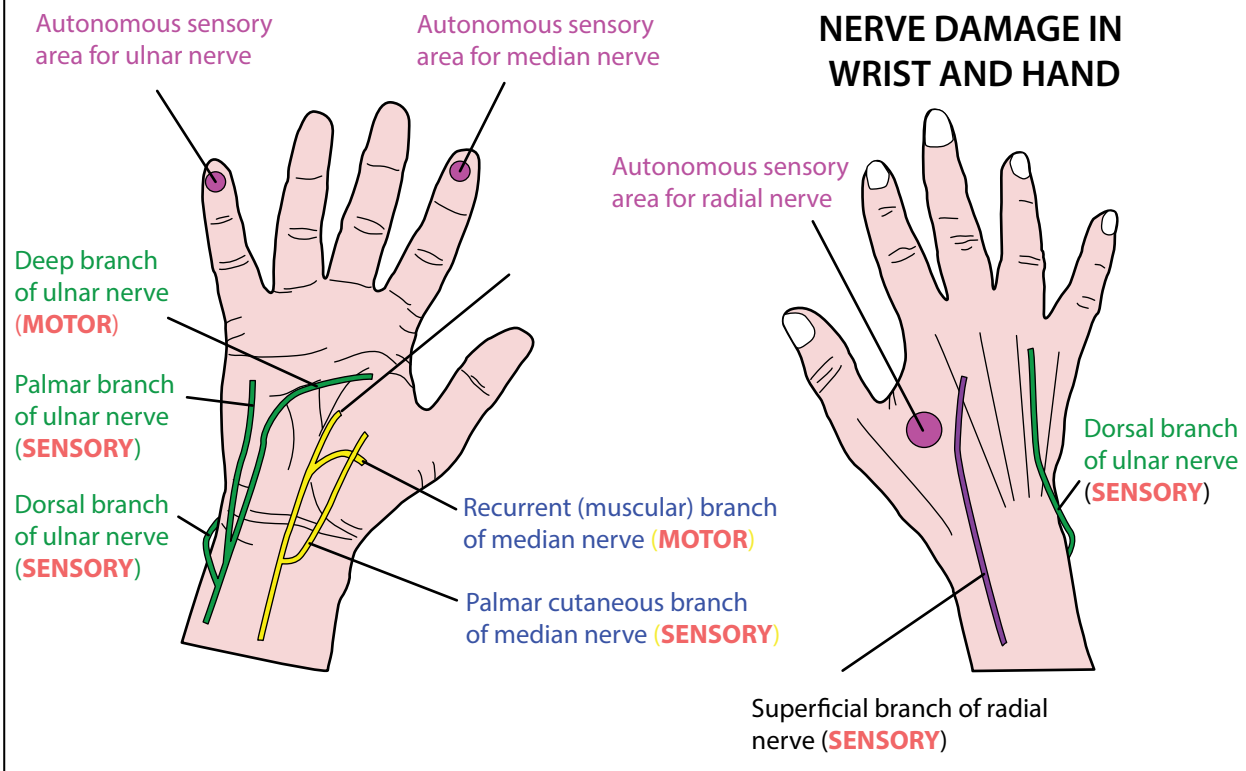
DETAILS OF LONG FLEXOR TENDONS IN FINGERS 1



DETAILS OF LONG FLEXOR TENDONS IN FINGERS 2



NERVE DAMAGE IN WRIST AND HAND



SECTION 2

Lower Limb

2.1 Nerves, Vessels and Lymphatics, *82*
2.2 Gluteal Region, Hip and Thigh, *99*
2.3 Knee and Popliteal Fossa, *116*
2.4 Lower Leg, *125*
2.5 Ankle and Foot, *132*

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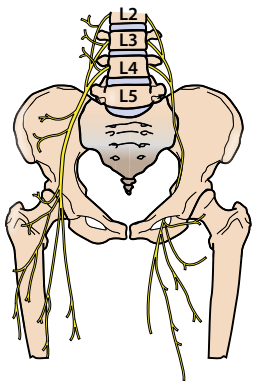
2.1 Nerves, Vessels and Lymphatics

INTERNAL ROTATION OF LOWER LIMB DURING DEVELOPMENT

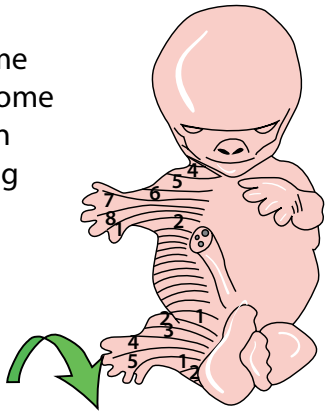


FEMORAL NERVE (L2,3,4 posterior divisions)

OBTURATOR NERVE (L2,3,4 anterior divisions)

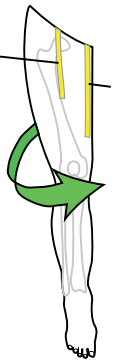
In utero, the lower limb bud grows out laterally but it then internally rotates so that the extensor to the knee (vasti) lie on the anterior aspect of the thigh. In contrast, the upper limb rotates externally so that extensors of the elbow (triceps) lie posteriorly

Dermatome and myotome patterns in developing limb buds



Femoral nerve becomes anterior

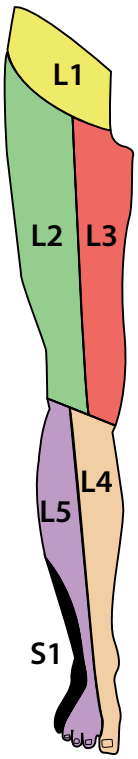
Obturator nerve becomes postero/ medial



Internal rotation during adaptation to bipedalism and upright position

SIMPLIFIED DERMATOMES OF LOWER LIMB

These are approximate dermatomes that are perfectly adequate for most clinical practice and for testing, for instance, in lumbar disc lesions. (See "dermatome dance" for an easy way of remembering and demonstrating them)

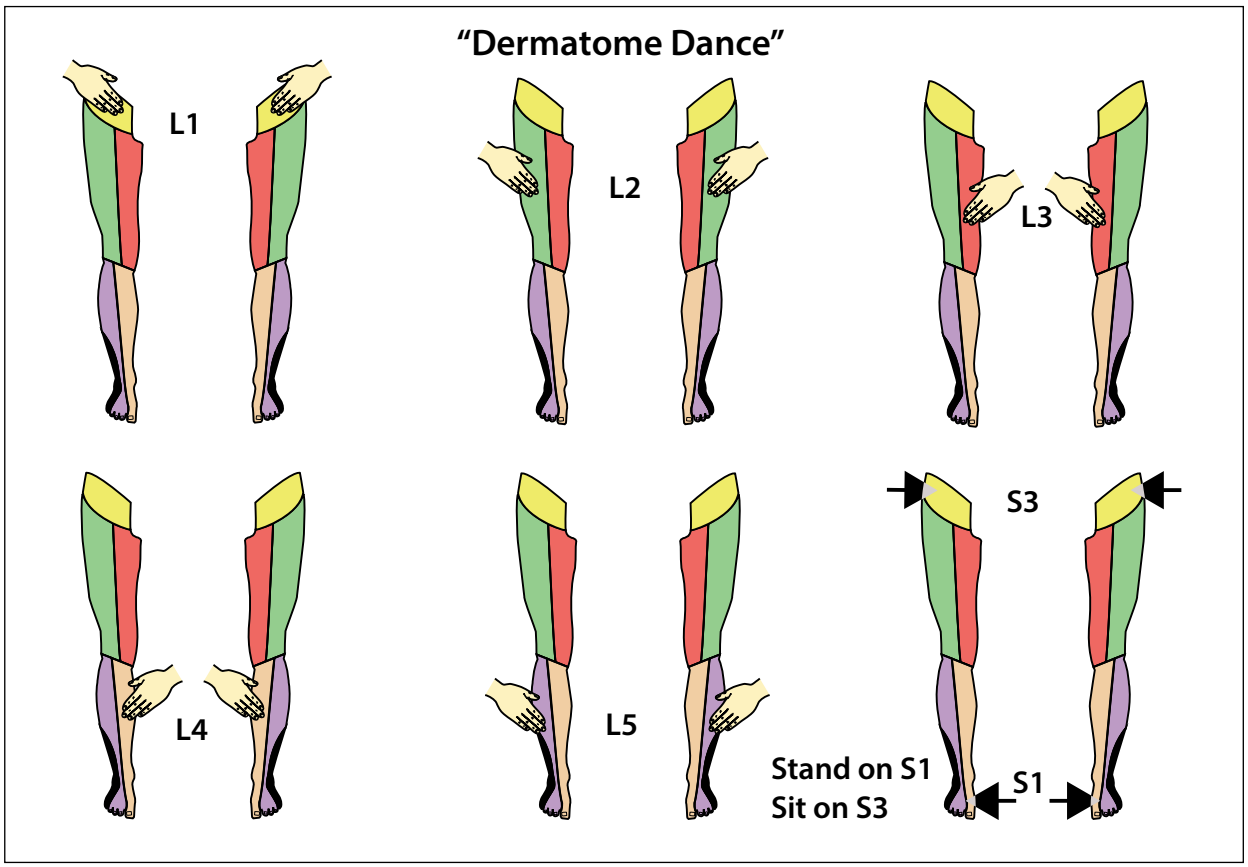


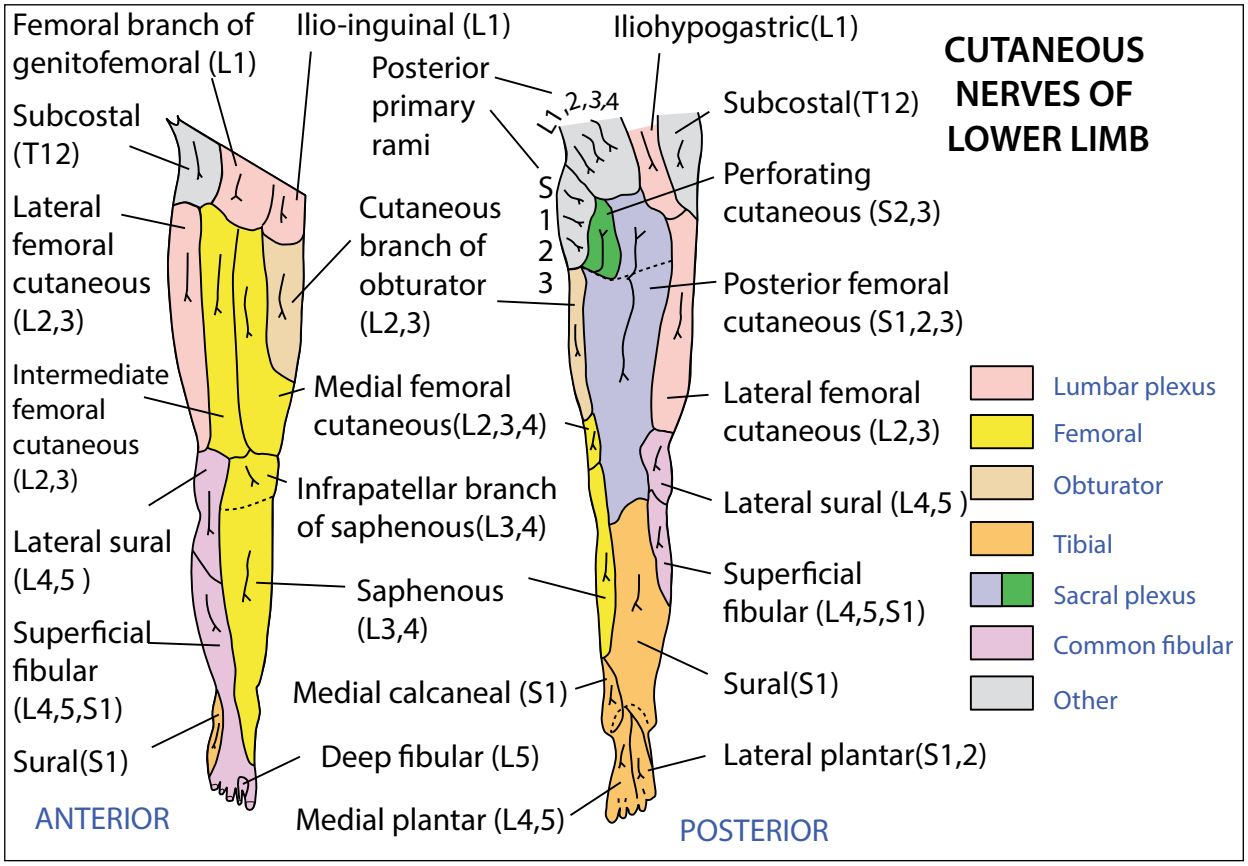
T12 Suprapubic area

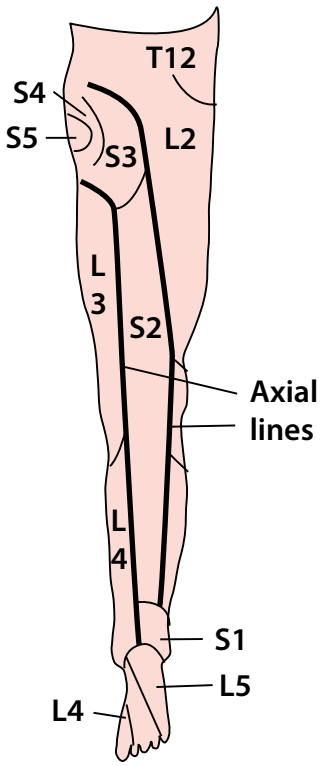
L1 Hand's breadth below inguinal ligament, side of penis and scrotum

Stand on S1 - Sit on S3

Across foot on both dorsal and plantar surfaces from medial to lateral is **L4 - L5 - S1**


"Dermatome Dance"
L1
L2
L3
L4
L5
S3
S1
Stand on S1
Sit on S3


CUTANEOUS NERVES OF LOWER LIMB
Femoral branch of genitofemoral (L1)
Ilio-inguinal (L1)
Iliohypogastric(L1)
Subcostal (T12)
Posterior primary rami
L1
2,3,4
S
1
2
3
Subcostal(T12)
Perforating cutaneous (S2,3)
Lateral femoral cutaneous (L2,3)
Cutaneous branch of obturator (L2,3)
Posterior femoral cutaneous (S1,2,3)
Intermediate femoral cutaneous (L2,3)
Medial femoral cutaneous(L2,3,4)
Lateral femoral cutaneous (L2,3)
Infrapatellar branch of saphenous(L3,4)
Lateral sural (L4,5)
Lateral sural (L4,5)
Saphenous (L3,4)
Superficial fibular (L4,5,S1)
Superficial fibular (L4,5,S1)
Medial calcaneal (S1)
Sural(S1)
Sural(S1)
Deep fibular (L5)
Lateral plantar(S1,2)
Medial plantar (L4,5)
ANTERIOR
POSTERIOR
Lumbar plexus
Femoral
Obturator
Tibial
Sacral plexus
Common fibular
Other



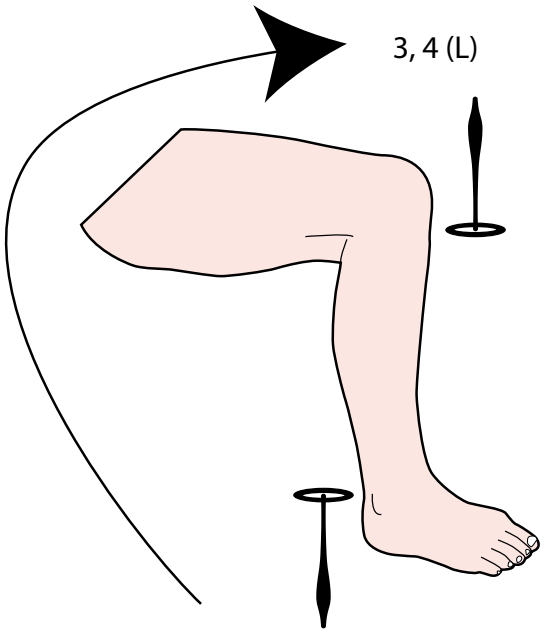
LOWER LIMB POSTERIOR DERMATOMES

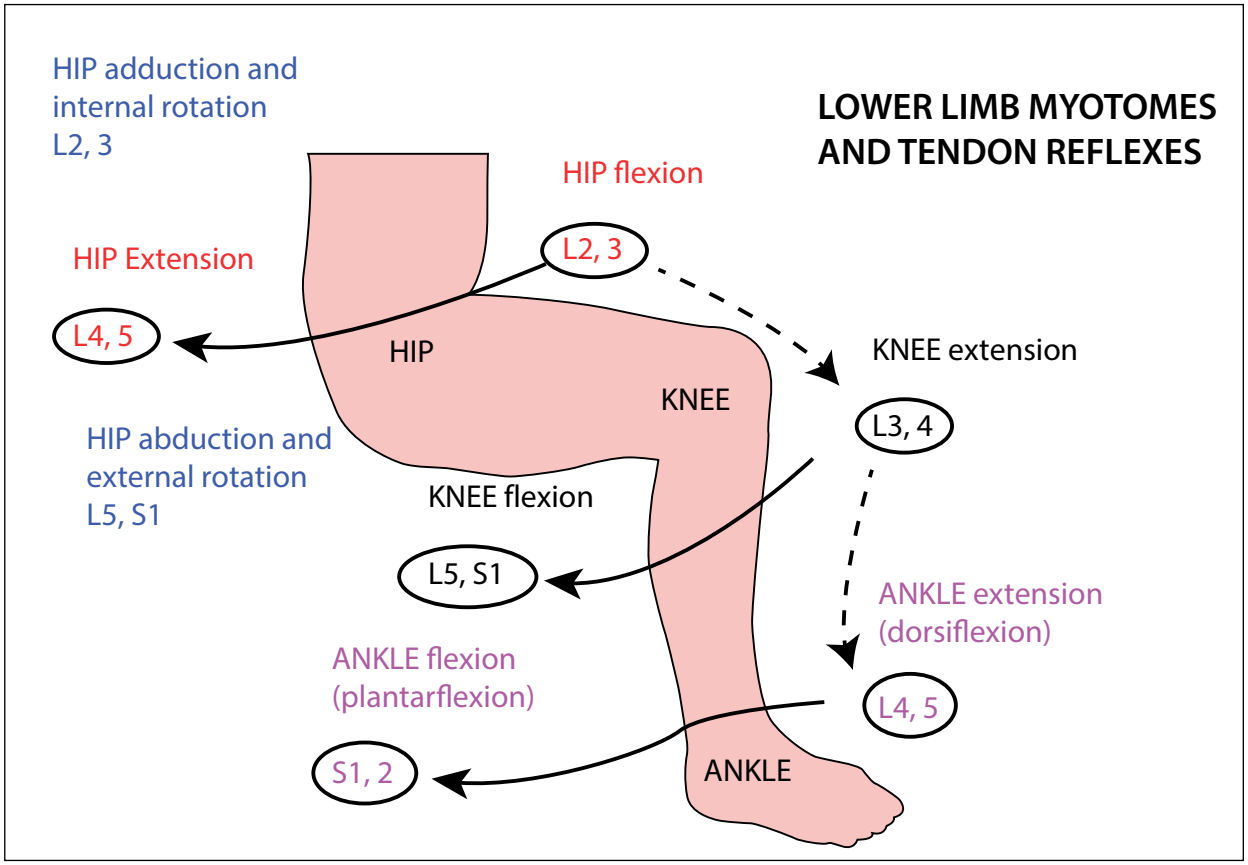
Notes:

The final position of the dermatomes in the leg are affected by the internal rotation of the limb as we become upright.

The axial lines denote the separation of non-contiguous dermatomes where there is no overlap of sensation.

LOWER LIMB TENDON REFLEXES

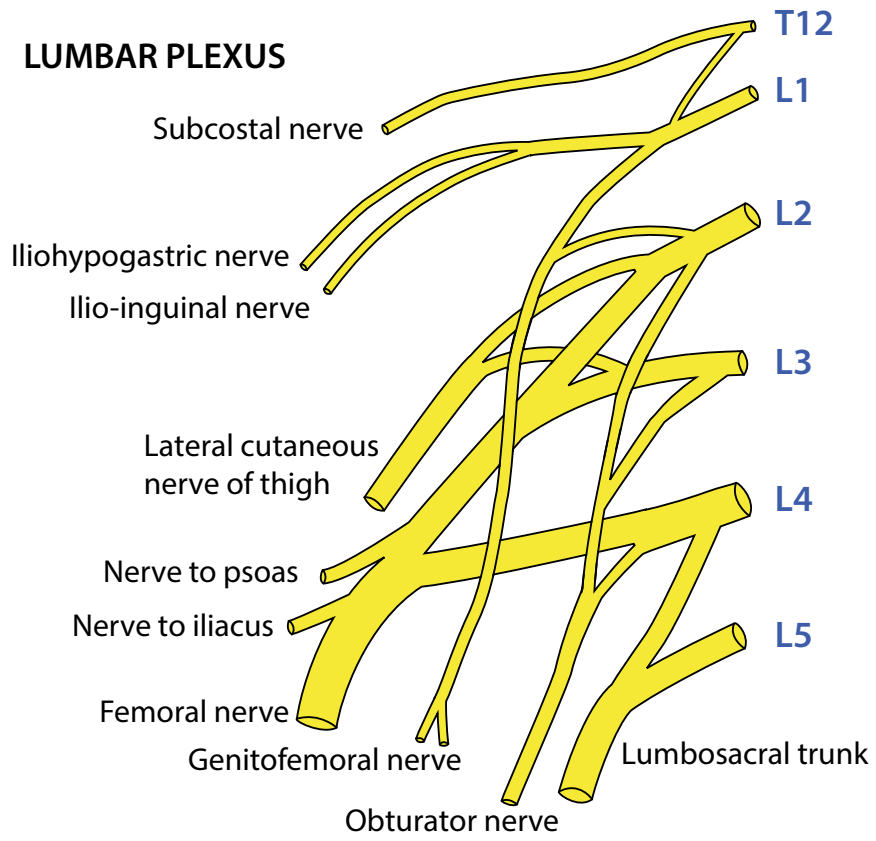




SEGMENTAL NERVE SUPPLY FOR MOVEMENTS AND REFLEXES IN LOWER LIMB

HIP:	Flexion	L2,3
	Extension	L4,5
	Adduction/internal rotation	L1,2,3
	Abduction/external rotation	L5,S1
KNEE:	Flexion	L5,S1
	Extension	L3,4
ANKLE:	Dorsiflexion (extension)	L4,5
	Plantarflexion (flexion)	S1,2

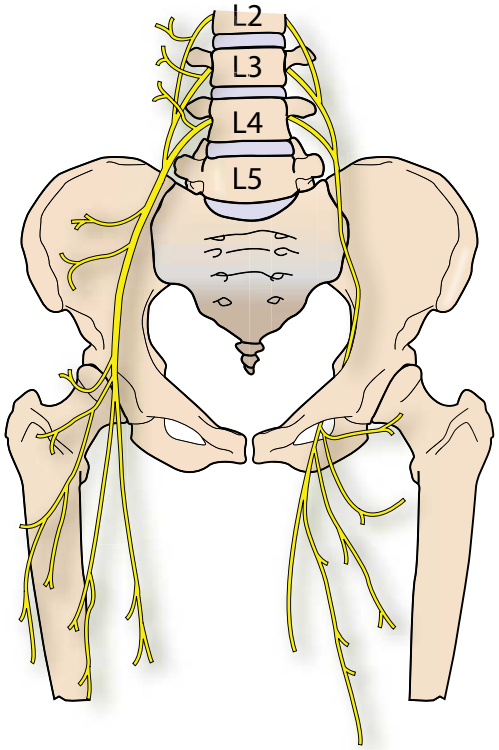
LUMBAR PLEXUS



FEMORAL AND OBTURATOR NERVES

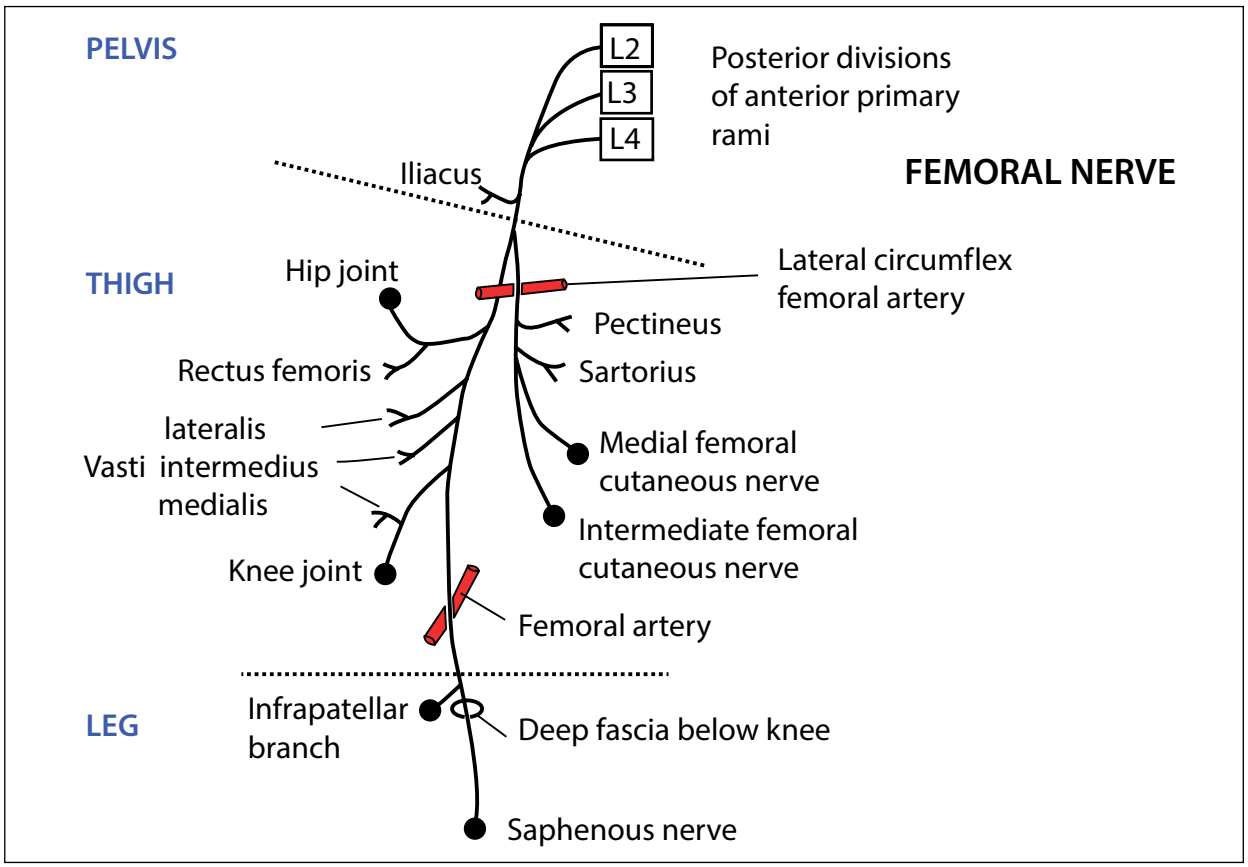
FEMORAL NERVE (L2,3,4 **POSTERIOR** DIVISIONS)

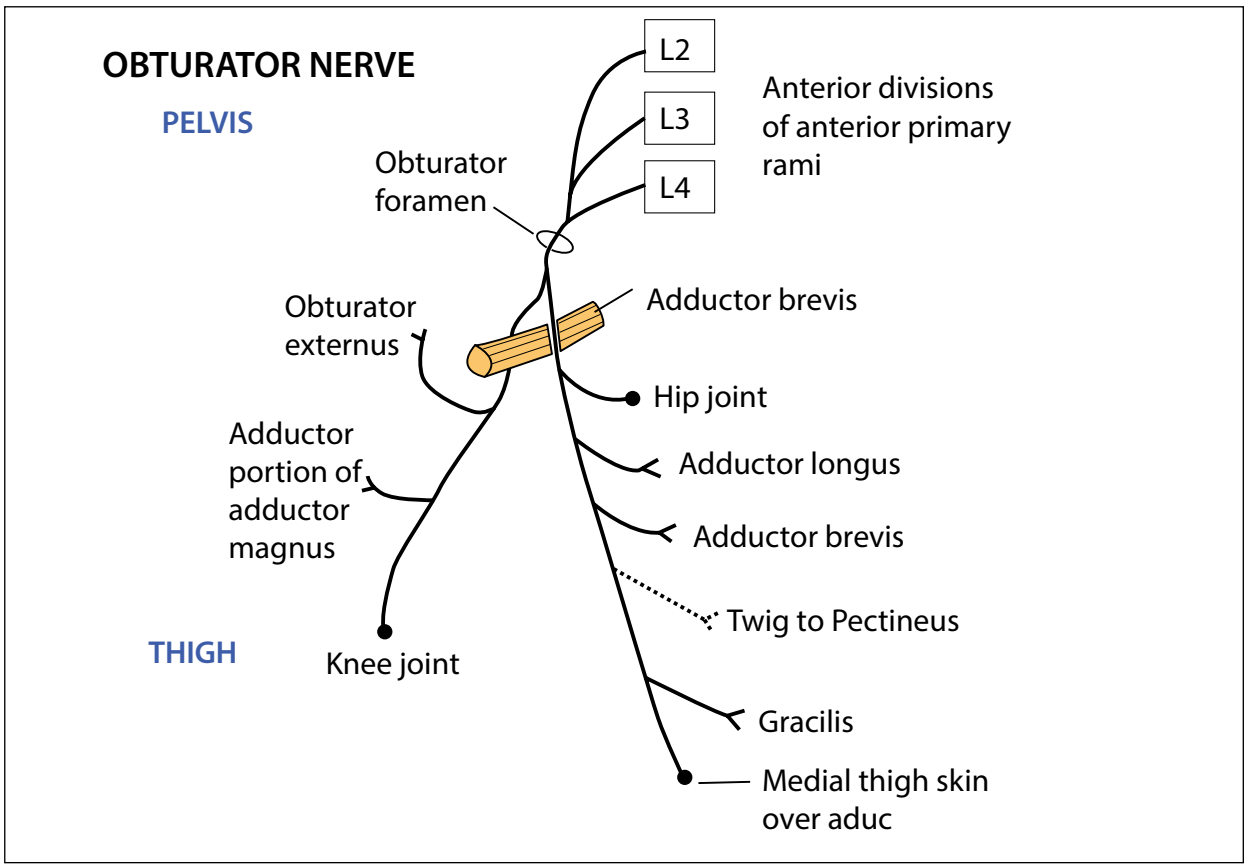
Muscles: Quadriceps, sartorius, pectineus
Cutaneous: Anterior and medial thigh. Saphenous nerve to medial leg and foot



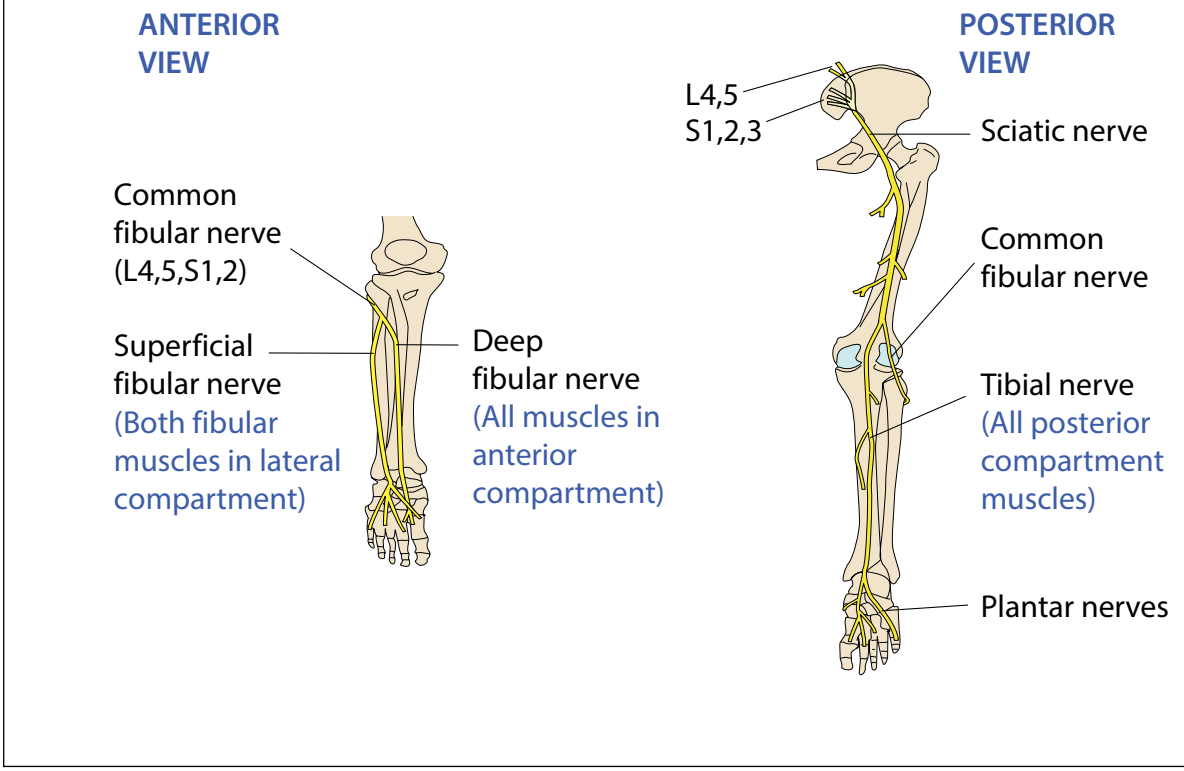
OBTURATOR NERVE (L2,3,4 **ANTERIOR** DIVISIONS)

Muscles: Adductors
Cutaneous: Medial thigh, hip and knee joint

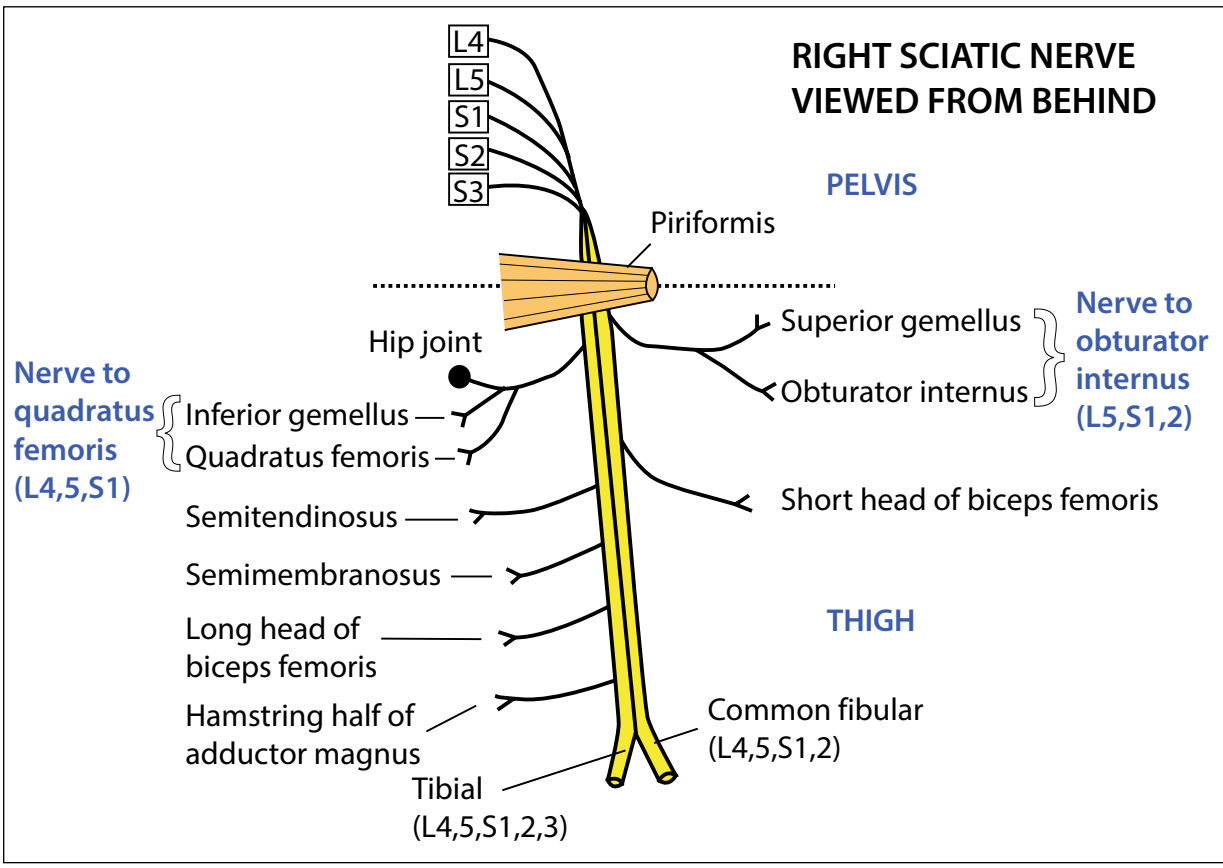

PELVIS
L2
L3
L4
Posterior divisions of anterior primary rami
FEMORAL NERVE
Iliacus
THIGH
Hip joint
Lateral circumflex femoral artery
Pectineus
Rectus femoris
Sartorius
lateralis
Vasti intermedius
medialis
Medial femoral cutaneous nerve
Intermediate femoral cutaneous nerve
Knee joint
Femoral artery
LEG
Infrapatellar branch
Deep fascia below knee
Saphenous nerve


OBTURATOR NERVE
PELVIS
L2
L3
L4
Anterior divisions of anterior primary rami
Obturator foramen
Obturator externus
Adductor brevis
Hip joint
Adductor portion of adductor magnus
Adductor longus
Adductor brevis
Twig to Pectineus
THIGH
Knee joint
Gracilis
Medial thigh skin over aduc

SCIATIC NERVE



RIGHT SCIATIC NERVE VIEWED FROM BEHIND



TIBIAL NERVE
(L4,5,S1,2,3)

Leaves the sciatic nerve in lower thigh to lie centrally in popliteal fossa, between, and deep to, semitendinosus and biceps femoris. It passes into the lower leg under the fibrous arch of soleus, lies on tibialis posterior heading medially to pass posterior to the medial malleolus, beneath the flexor retinaculum.

BRANCHES IN THIGH TO:
Motor - gastrocnemius, popliteus, plantaris
Sensory - knee and superior tibiofibular joints, sural to posterolateral calf skin and lateral foot (sural communicating nerve from common fibular joins it)

BRANCHES IN LEG TO:
Motor - soleus, tibialis posterior, flexor digitorum longus, flexor hallucis longus
Sensory - ankle joint, medial calcaneal nerve to heel and medial sole skin

BRANCHES IN FOOT TO:
Motor and sensory - medial and lateral plantar nerves
(see other image for details)

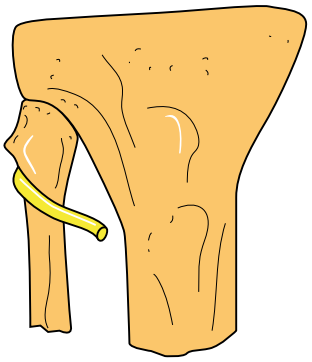
COMMON FIBULAR NERVE - L4,5,S1,2

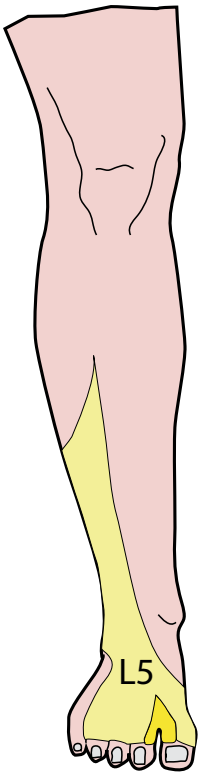
Leaves the sciatic nerve in lower thigh to lie laterally in popliteal fossa, deep to biceps femoris, then on plantaris and lateral head of gastrocnemius before winding around the neck of the fibula. It enters fibularis longus where it divides into its superficial and deep branches.

BRANCHES LEAVING IN THIGH TO:
Sensory - Sural communicating which joins sural (see tibial nerve), knee and superior tibiofibular joints, lateral sural to upper lateral calf skin.
Motor - Note that short head of biceps femoris is supplied by the common fibular portion of the sciatic nerve

BRANCHES LEAVING IN LEG AND FOOT TO:
Superficial fibular:
Motor - Fibularis longus and brevis
Sensory - Dorsal skin of foot excluding nail beds and first dorsal webspace
Deep fibular:
Motor - Tibialis anterior, extensor digitorum longus, extensor hallucis longus, fibularis tertius, extensor digitorum brevis
Sensory - Skin of first dorsal webspace

COMMON FIBULAR NERVE





The common fibular nerve winds around the neck of the fibula before dividing into its deep and superficial branches. Pressure here from too tight a plaster or trauma can lead to **foot drop and sensory changes** in the skin of the lateral lower leg and foot as seen in a L4/5 disc lesion involving the L5 root.

MEDIAL AND LATERAL PLANTAR NERVES

As the tibial nerve passes deep to the flexor retinaculum it gives off the medial and lateral plantar nerves

MEDIAL PLANTAR NERVE (L4,5,S1,2,3)
Motor - flexor digitorum brevis, flexor hallucis brevis, abductor hallucis, 1st lumbrical (all muscles supplied by S1,2 except 1st lumbrical which is S2,3)
Sensory - skin of most of sole and medial 3 and a half toes and nail beds (L4,5)

LATERAL PLANTAR NERVE (S1,2,3)
Motor - abductor digiti minimi, flexor digiti minimi brevis, flexor digitorum accessorius, all 7 interossei, 2nd, 3rd, 4th lumbricals, adductor hallucis (all muscles supplied by S2,3)
Sensory - skin of lateral sole and lateral one and a half toes and nail beds (S1)

NOTE: It is worth comparing the medial plantar nerve with the median in the hand and the lateral plantar nerve with the ulnar nerve in the hand. The similarities are obvious and the only significant differences are that the line of action of the interossei is along the second toe, a single lumbrical is supplied by the medial plantar nerve and that there is an extra muscle in the foot - flexor digitorum accessorius

SEGMENTAL NERVE SUPPLY TO MUSCLES 1

L1,2	Psoas minor	Segmental
L1,2,3	Psoas major	Segmental
L2,3	Adductor brevis	Obturator
L2,3	Gracilis	Obturator
L2,3	Sartorius	Femoral
L2,3	Iliacus	Femoral
L2,3	Pectineus	Femoral (+/- obturator)
L2,3,4	Rectus femoris	Femoral
L2,3,4	Adductor magnus	Obturator & sciatic (tibial portion)
L2,3,4	All 3 Vasti	Femoral
L2,3,4	Adductor longus	Obturator
L3,4	Obturator externus	Obturator
L4,5	Tibialis anterior	Deep fibular
L4,5	Tibialis posterior	Tibial

SEGMENTAL NERVE SUPPLY TO MUSCLES 2

L4,5,S1	Gluteus medius	Superior gluteal
L4,5,S1	Gluteus minimis	Superior gluteal
L4,5,S1	Inferior gemellus	N to quadratus femoris
L4,5,S1	Popliteus	Tibial
L4,5,S1	Quadratus femoris	N to quadratus femoris
L4,5,S1	Tensor fasciae latae	Superior gluteal
L5,S1	Extensor digitorum longus	Deep fibular
L5,S1	Extensor hallucis longus	Deep fibular
L5,S1	Fibularis tertius	Deep fibular
L5,S1	Extensor hallucis brevis	Deep fibular
L5,S1,2	Fibularis brevis	Superficial fibular
L5,S1,2	Fibularis longus	Superficial fibular
L5,S1,2	Semimembranosus	Sciatic (tibial portion)
L5,S1,2	Semitendinosus	Sciatic (tibial portion)
L5,S1,2	Gluteus maximus	Inferior gluteal
L5,S1,2	Obturator internus	N to obturator internus
L5,S1,2	Superior gemellus	N to obturator internus
L5,S1,2	Biceps femoris (both heads)	Sciatic (tibial & common fibular)

SEGMENTAL NERVE SUPPLY TO MUSCLES 3

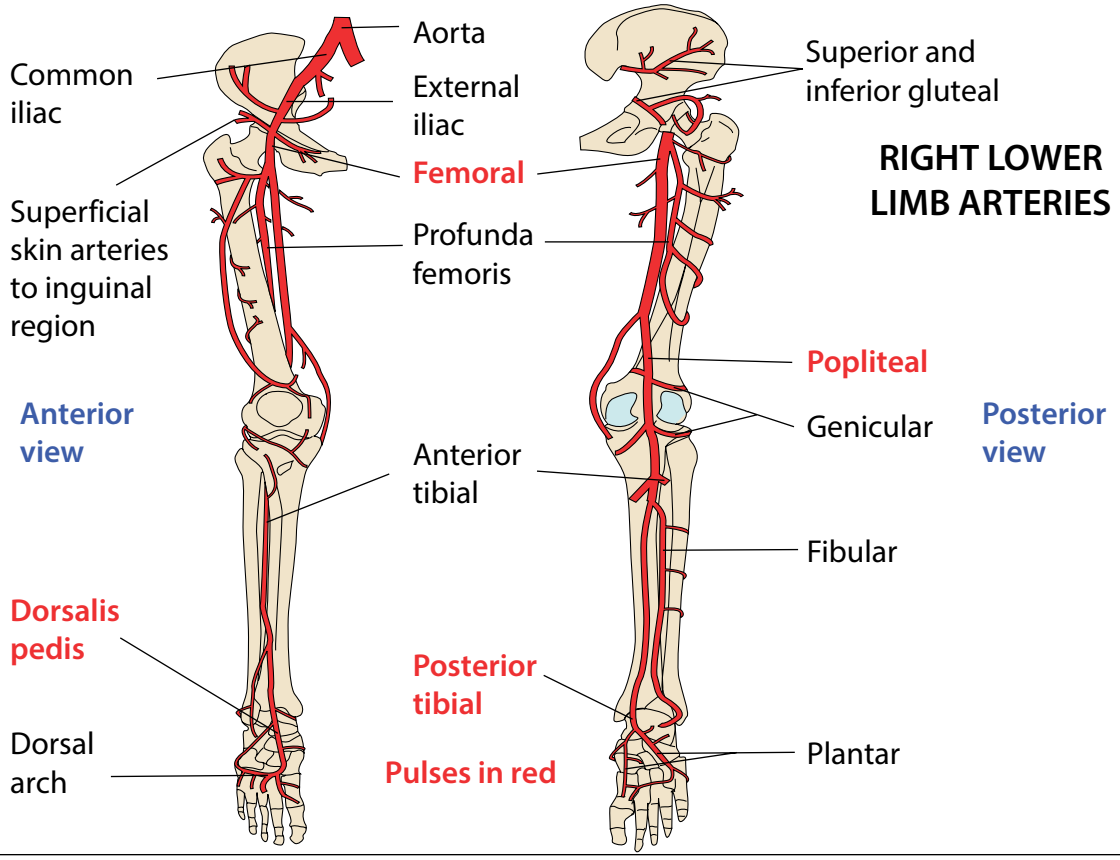
S1,2	Extensor digitorum brevis	Deep fibular
S1,2	Soleus	Tibial
S1,2	Plantaris	Tibial
S1,2	Gastrocnemius	Tibial
S1,2	Piriformis	N to piriformis
S2,3	Abductor hallucis	Medial plantar
S2,3	Flexor digitorum brevis	Medial plantar
S2,3	Flexor hallucis brevis	Medial plantar
S2,3	Lumbricals	Medial & lateral plantar
S2,3	Abductor digiti minimi	Lateral plantar
S2,3	Adductor hallucis	Lateral plantar
S2,3	Flexor digiti minimi brevis	Lateral plantar
S2,3	Flexor digitorum longus	Tibial
S2,3	Flexor hallucis longus	Tibial
S2,3	Interossei	Lateral plantar
S2,3	Quadratus plantae (Flex. dig. accessorius)	Lateral plantar

NERVE LESIONS IN THE LOWER LIMB 1

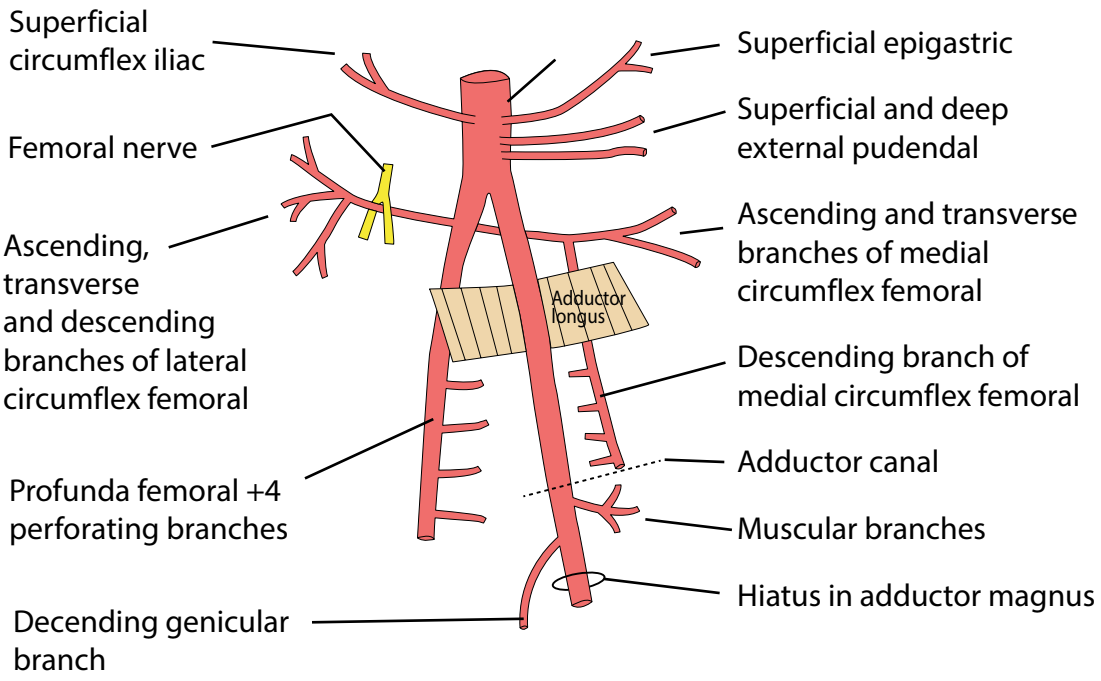
NERVES TO PSOAS AND ILIACUS	No pelvic swing on walking ↓ in hip flexion
FEMORAL	↓ in hip flexion and loss of knee extension Loss of sensation anterior thigh and medial leg
OBTURATOR	Loss of adduction of thigh Loss of sensation inner thigh
SUPERIOR GLUTEAL	Loss of abduction at hip Pelvic dip on walking
INFERIOR GLUTEAL	↓ in extension at hip Buttock wasting

NERVE LESIONS IN THE LOWER LIMB 2

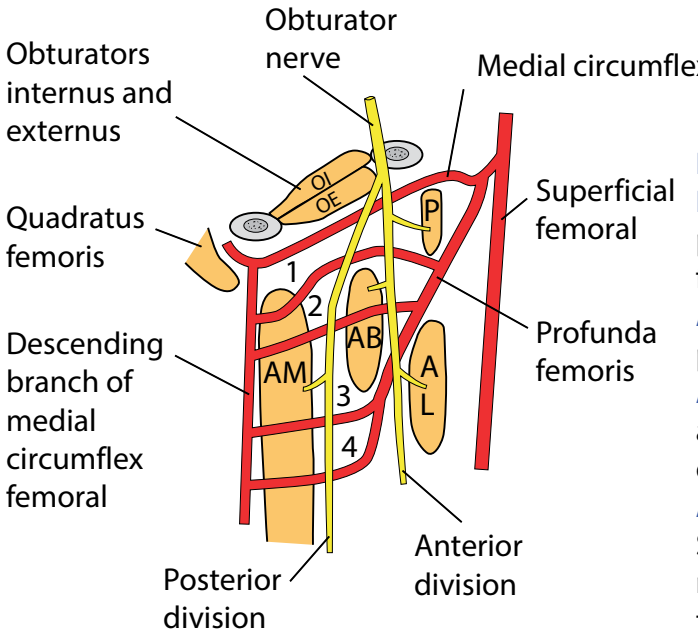
SCIATIC	Loss of all motor except adduction and flexion of thigh and extension of knee. Loss of sensation lower leg and foot
TIBIAL (HIGH)	Loss of flexion of toes and inversion of foot. Loss of sensation of sole of foot, inferior aspect of toes and nail beds
COMMON FIBULAR (HIGH)	Loss of extension of toes and foot (footdrop). Loss of sensation of lateral lower leg and upper foot
ROOT COMPRESSION	Prolapsed discs compresses nerve that emerges at the next intervertebral foramen and not usually the one at the same level as the disc. For example, disc lesion of the L4/5 space compresses L5 nerve



RIGHT FEMORAL ARTERY



PROFUNDA FEMORIS ARTERY



RELATIONSHIPS

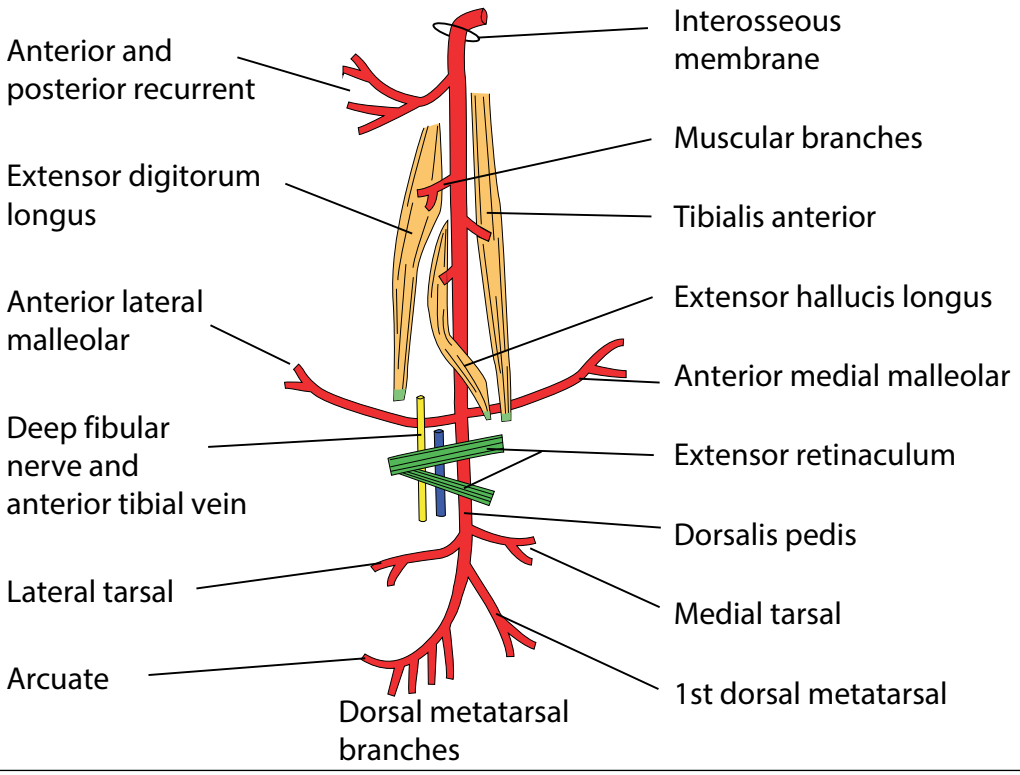
Pectineus (P): Separates profunda from medial circumflex femoral artery

Adductor longus (AL): Separates profunda from femoral artery

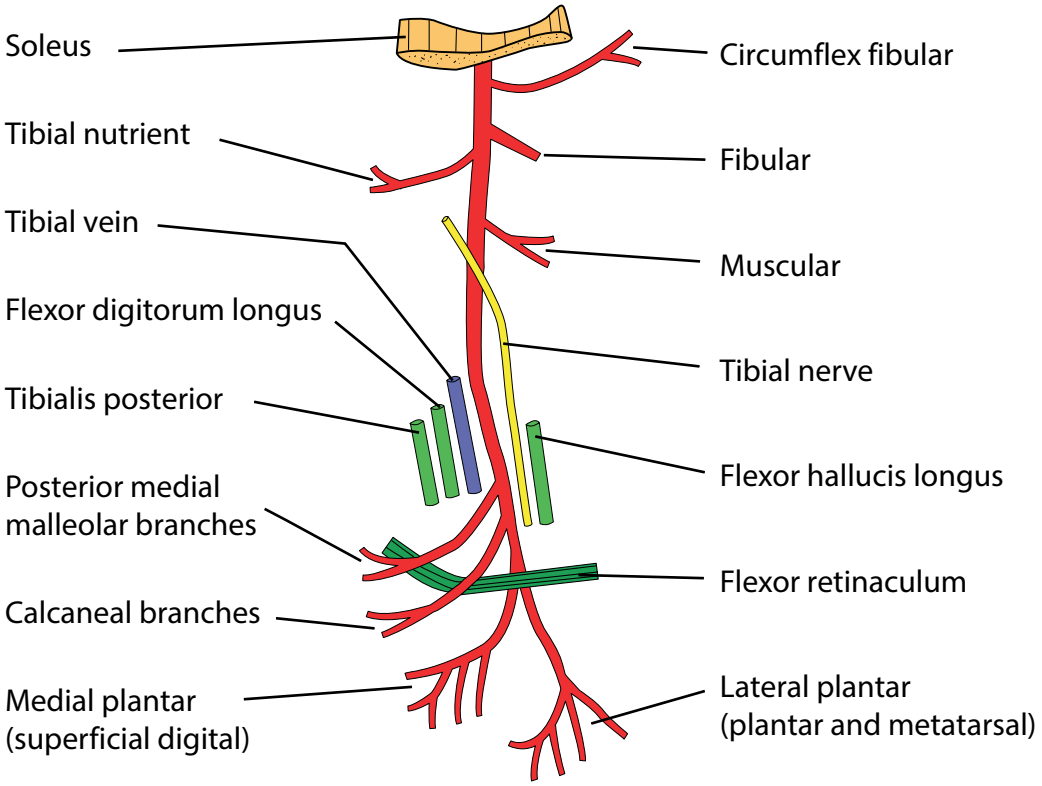
Adductor brevis (AB): Separates anterior and posterior divisions of obturator nerve

Adductor magnus (AM): Separates descending branch of medial circumflex femoral artery from profunda

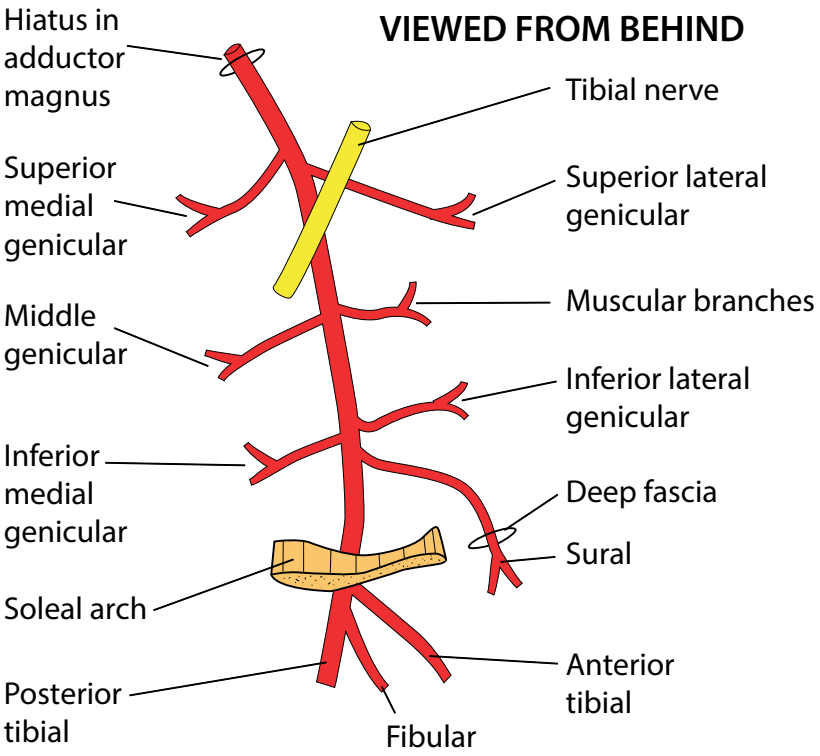
RIGHT ANTERIOR TIBIAL ARTERY VIEWED FROM IN FRONT



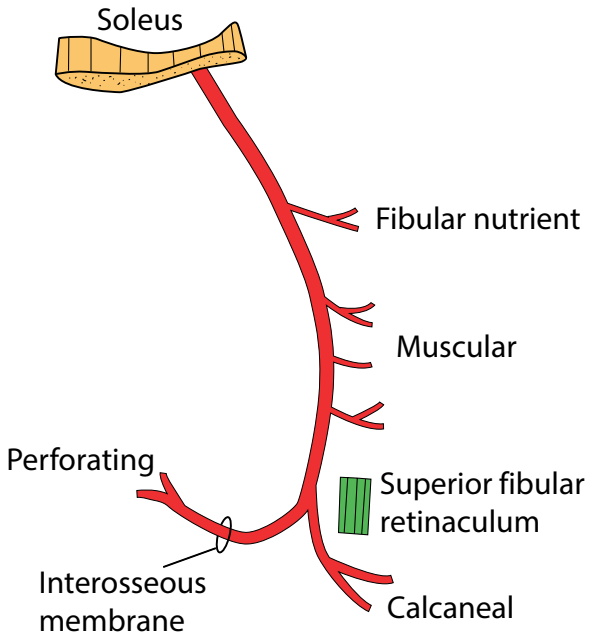
RIGHT POSTERIOR TIBIAL ARTERY VIEWED FROM BEHIND



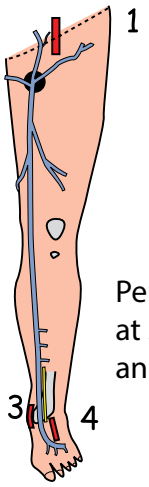
RIGHT POPLITEAL ARTERY VIEWED FROM BEHIND



RIGHT FIBULAR ARTERY VIEWED FROM BEHIND



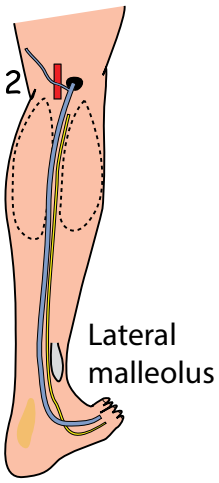
VEINS AND PULSES IN THE LOWER LIMB



Anterior
GREAT (LONG) SAPHENOUS VEIN

Perforating veins at 3,6,9cm above ankle

Posterolateral
SMALL (SHORT) SAPHENOUS VEIN

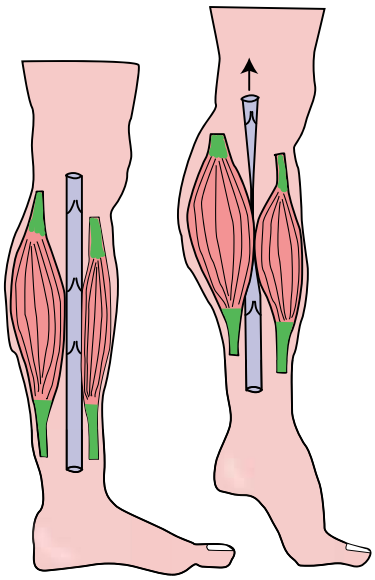


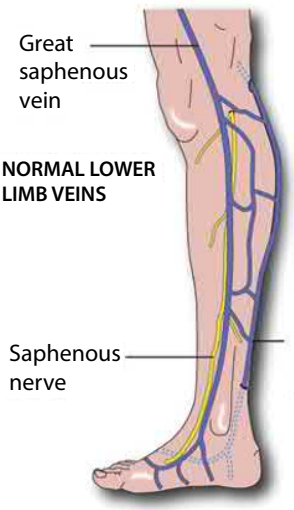
Pulses
1. Femoral in groin
2. Popliteal in popliteal fossa
3. Posterior tibial behind medial malleolus
4. Dorsalis pedis on dorsum of foot

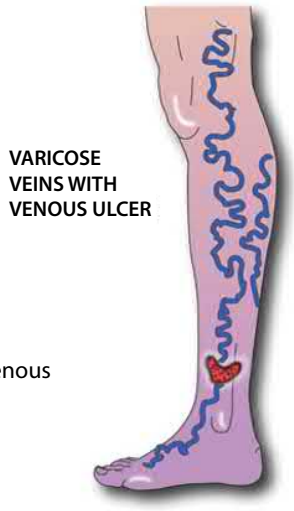
Great saphenous vein
Starts: Medial side of dorsal venous arch
Passes: Anterior to medial malleolus with saphenous nerve then a hand's breadth posteromedial to patella

Small saphenous vein
Starts: Lateral side of dorsal venous arch
Passes: Behind lateral malleolus then upwards on post aspect of calf with sural nerve.
Perforates: Popliteal fascia and joins popliteal vein at a variable site

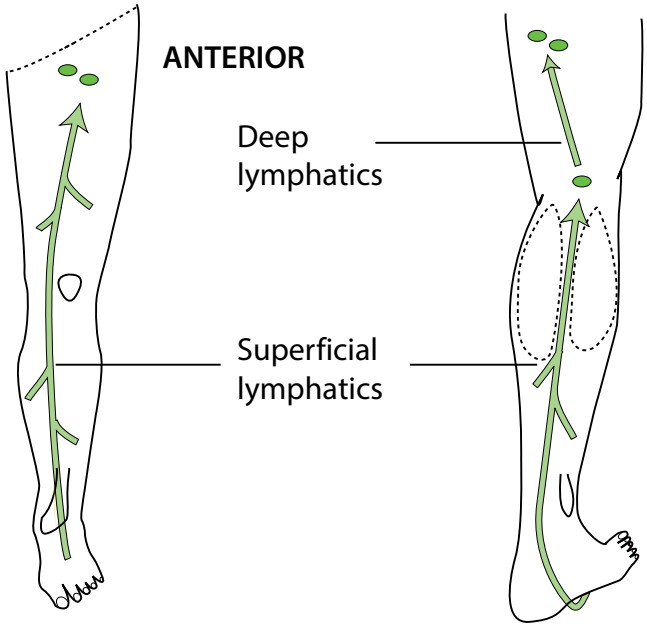
VENOUS RETURN FROM THE LEG







Venous blood in the superficial veins enters the deep veins via the perforator veins and is then pumped centrally by the muscle pumps (soleus and gastrocnemius) with the aid of valves. Failure of this mechanism leads to varicose veins and possible ulceration.

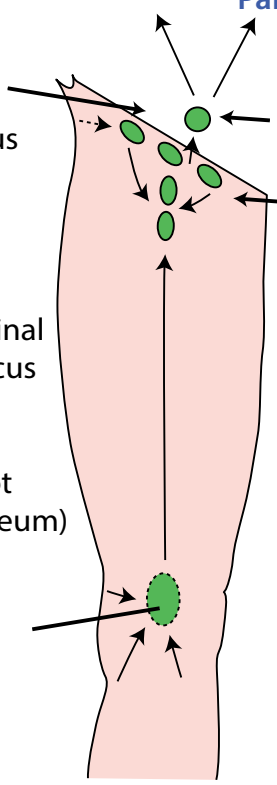


PATTERN OF LYMPHATIC DRAINAGE IN LOWER LIMB

Lymphatics from dorsum of foot, anterior leg and thigh run superficially following the great saphenous vein to the superficial inguinal lymph nodes

Lymphatics from sole of the foot and posterior leg run superficially with the short saphenous vein to the popliteal lymph nodes. Then with the deep veins to the inguinal lymph nodes

LOWER LIMB LYMPHATICS



Iliac and lateral pelvic

Para-aortic

Superficial inguinal

(Uterine fundus
Skin of penis
Labia minora
Scrotum
Buttock skin
Lower abdominal wall to umbilicus
Thigh
Anterior calf
Dorsum of foot
Anterior perineum)

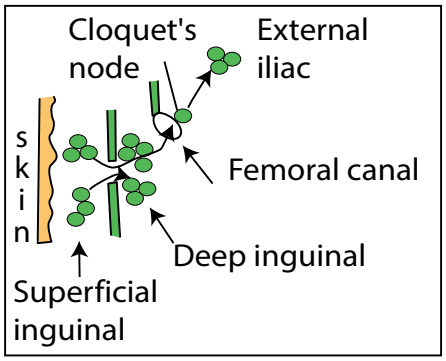
Cloquet's node is high in the femoral canal, medial to femoral vein, lateral to lacunar ligament

Deep inguinal

(Anterior perineum
Thigh
Leg
Foot)

Popliteal

(Skin of sole of foot and posterior calf)



Leg
Medial thigh
Foot

↓

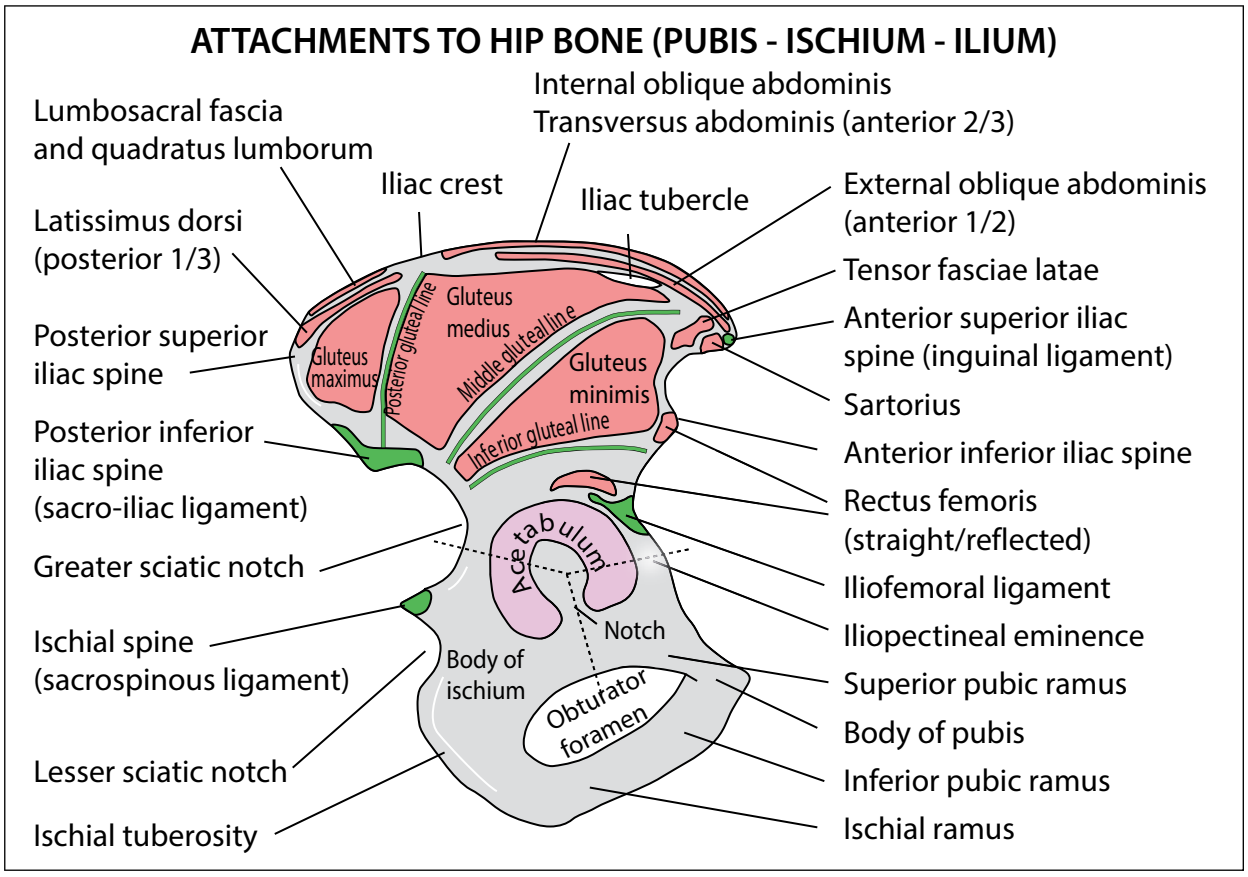
Superficial vertical group

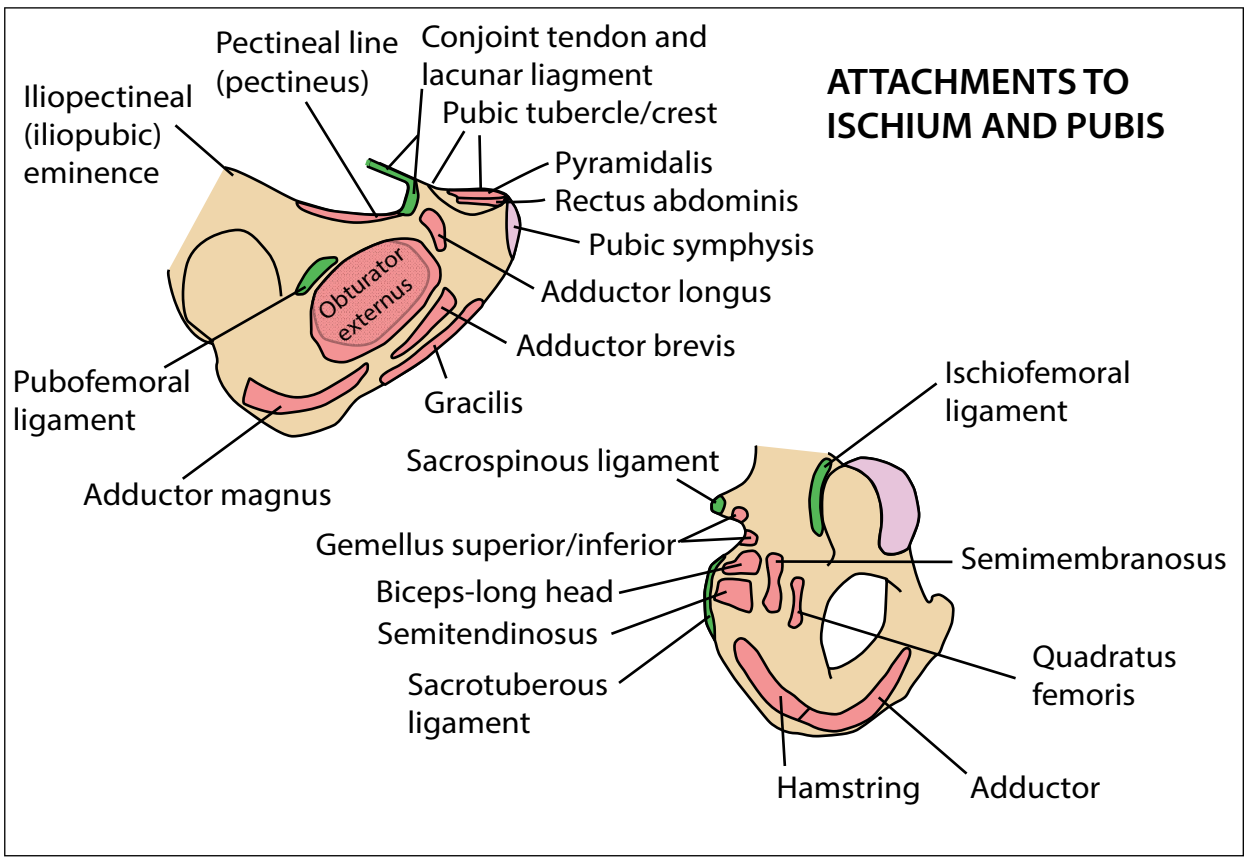
Buttocks
Abdominal wall
Perineum
lateral thigh

↓

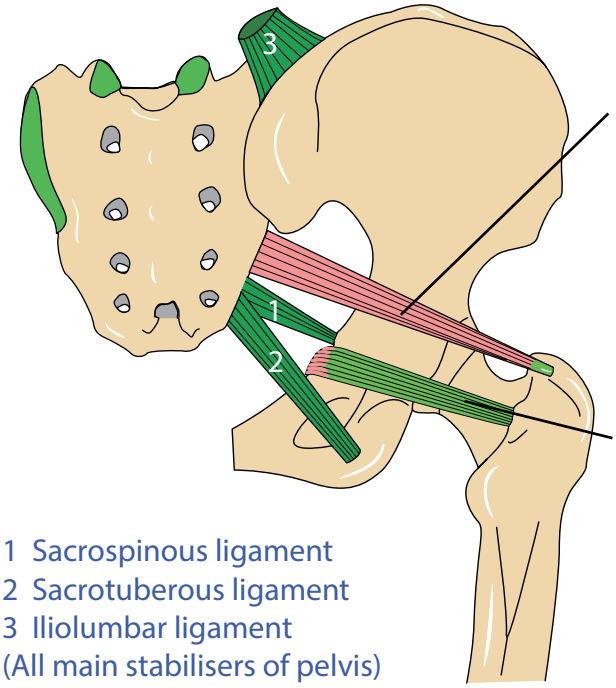
Superficial horizontal group

2.2 Gluteal Region, Hip and Thigh





GLUTEAL REGION - PIRIFORMIS AND OBTURATOR INTERNUS

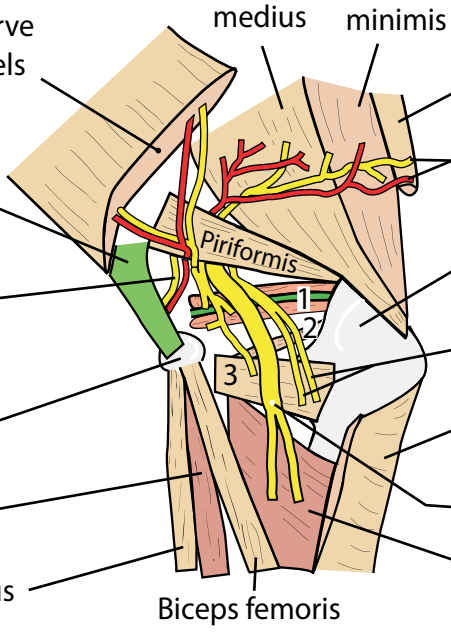


1 Sacrospinous ligament
2 Sacrotuberous ligament
3 Iliolumbar ligament
(All main stabilisers of pelvis)

Piriformis
From: Anterior surface of sacrum.
To: Greater trochanter of femur via greater sciatic foramen.
Action: Lateral rotator of hip
Nerve: S1,2

Obturator internus
From: Inner surface of obturator membrane
To: Medial aspect of greater trochanter of femur
Action: Lateral rotator of hip
Nerve: Nerve to obturator internus (L5,S1,2)

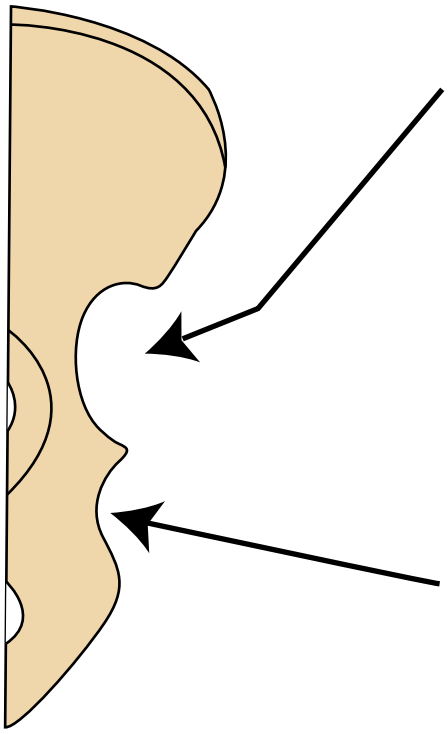
RIGHT GLUTEAL REGION



Gluteus maximus and inferior gluteal nerve (L5,S1,2) and vessels
Gluteus medius
Gluteus minimis
Tensor fasciae latae
Superior gluteal artery and nerve (L4,5,S1)
Sacrotuberous ligament
Greater trochanter
Internal pudendal artery and nerve (S2,3,4)
Cutaneous nerves
Ischial tuberosity
Cut lower end of gluteus maximus
Semitendinosus
Sciatic nerve
Semimembranosus
Adductor magnus
Biceps femoris

1 Gemellus superior, obturator internus, gemellus inferior
2 Obturator externus
3 Quadratus femoris

STRUCTURES PASSING THROUGH THE GREATER AND LESSER SCIATIC FORMINA



VIA GREATER SCIATIC FORAMEN

- Superior gluteal vessels
- Superior gluteal nerve (L4,5,S1)

PIRIFORMIS (S1,2)

- Inferior gluteal vessels
- Inferior gluteal nerve (L5,S1,2)
- Sciatic nerve (L4,5,S1,2,3)
- Perforating cutaneous nerve (S2,3)
- Posterior femoral cutaneous nerve (S1,2,3)
- Nerve to quadratus femoris (L4,5,S1)
- Nerve to obturator internus (L5,S1,2)
- Pudendal nerve (S2,3,4)
- Internal pudendal vessels

VIA LESSER SCIATIC FORAMEN

- Tendon of obturator internus
- Nerve to obturator internus
- Internal pudendal vessels
- Pudendal nerve

EASY WAY TO REMEMBER ROOT VALUES OF GLUTEAL MUSCLES

SHARE ROOT VALUES

SUPERIOR GLUTEAL NERVE - L 4, 5, S1
Gluteus medius, gluteus minimus, tensor fasciae latae

INFERIOR GLUTEAL NERVE - L 5, S1, 2
Gluteus maximus

NERVE TO OBTURATOR INTERNUS - L 5, S1, 2
Obturator internus, superior gemellus

NERVE TO QUADRATUS FEMORIS - L 4, 5, S1
Quadratus femoris, inferior gemellus

SCIATIC NERVE
Anterior division:
Tibial to flexors (L4,5,S1,2,3)
Nerve to obturator internus (L5,S1,2)
Nerve to quadratus femoris (L4,5,S1)

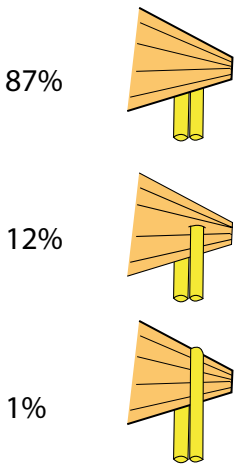
SCIATIC NERVE
Posterior division:
Common fibular to extensors
Superior gluteal (L4,5,S1)
Infe

There are six nerves that arise from the roots of the sacral plexus that have the letter "P"

Piriformis, nerve to :	S1,2	Remains in pelvis to supply this muscle
Posterior femoral cutaneous nerve:	S1,2,3	Leaves pelvis via greater sciatic foramen
Perforating cutaneous nerve:	S2,3	Leaves pelvis via greater sciatic foramen
Pudendal nerve:	S2,3,4	Leaves pelvis via greater sciatic foramen
Pelvic splanchnic (parasympathetic) nerves:	S2,3,4	Remains in pelvis to supply pelvic organs
Perineal branch of S4:	S4	Remains in pelvis to supply levator ani

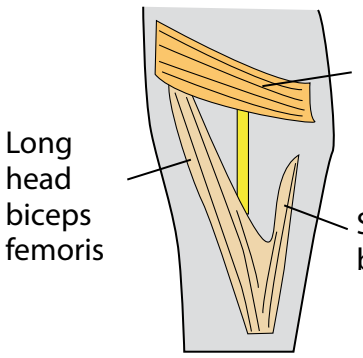
3 nerves remain in the pelvis and 3 exit via the greater sciatic foramen

VARIATIONS IN SCIATIC NERVE



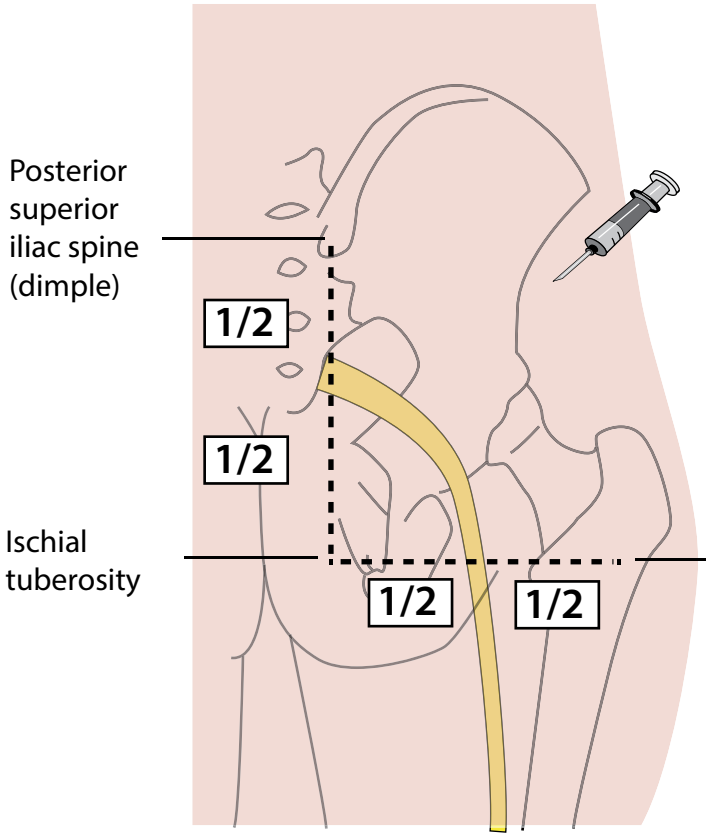
Variations in the emergence of common fibular nerve in relation to piriformis

Covered by



Nerve lies on:

- Superior gemellus
- Tendon of obturator internus
- Inferior gemellus
- Quadratus femoris
- Adductor magnus



SCIATIC NERVE

↓

BUTTOCK INJECTIONS

Upper outer quadrant to avoid the sciatic nerve

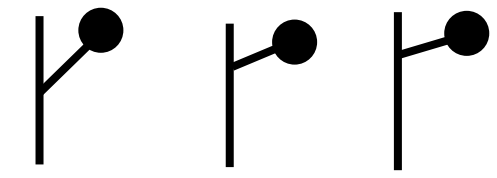
HIP JOINT 1

Ball and socket

Synovial

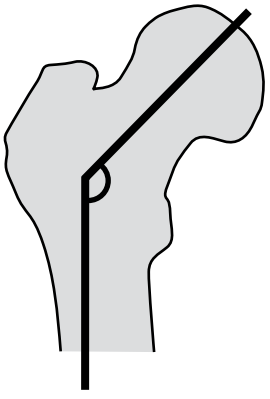
Ligamentum teres in fovea

ANGLE OF NECK ON SHAFT



CHILD MALE FEMALE

160^{o} 120^{o} 100^{o}

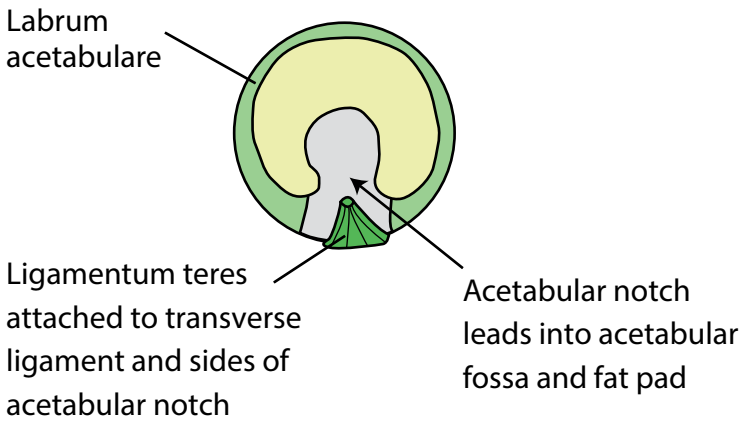


HIP JOINT 2

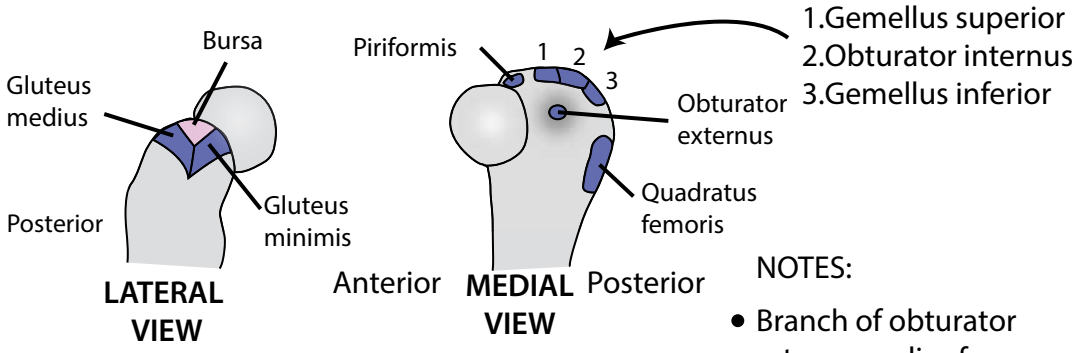
SYNOVIUM

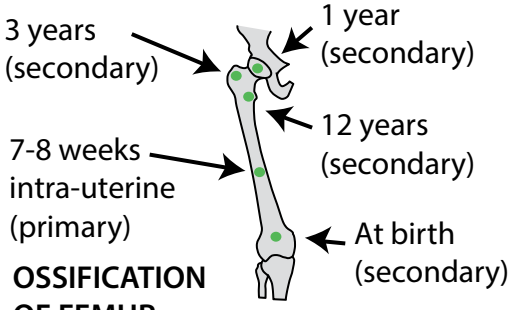
From: Femoral articular margin

Covers: Intracapular femoral neck, labrum, ligamentum teres, Havesian fat pad and may communicate with **psoas bursa**



ATTACHMENTS TO RIGHT FEMUR GREATER TROCHANTER

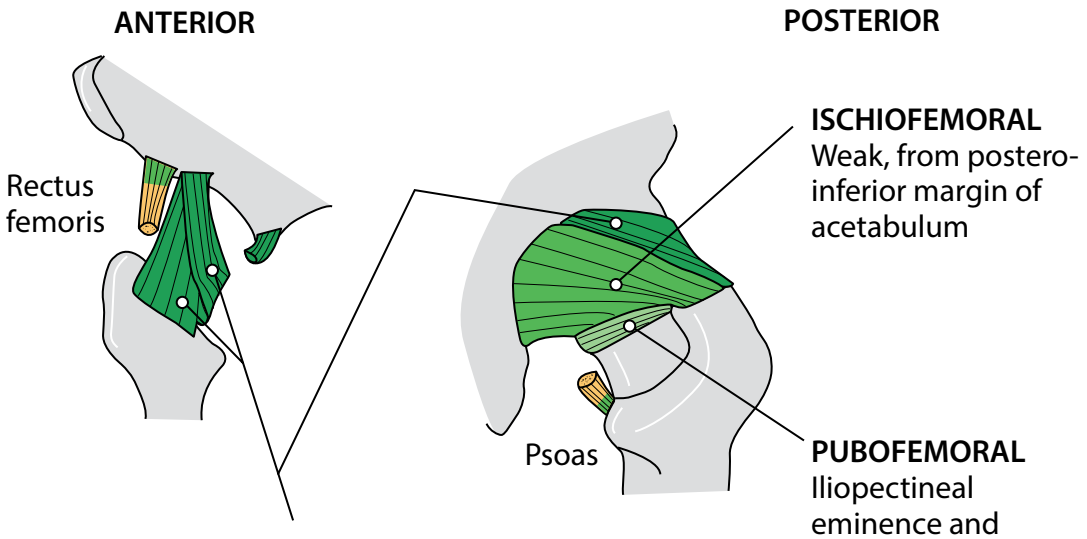




NOTES:

- Branch of obturator artery supplies fovea of femoral head via ligamentus teres.
- Growing ends of lower limb is either side of knee.
- Nutrient arteries enter obliquely at growing end.
- Femur is 1st long bone

HIP JOINT LIGAMENTS



Nerve supply of hip: According to Hilton's Law. This law states that the nerve supply of a joint is the same supply as to the muscles that move it

HIP JOINT 4

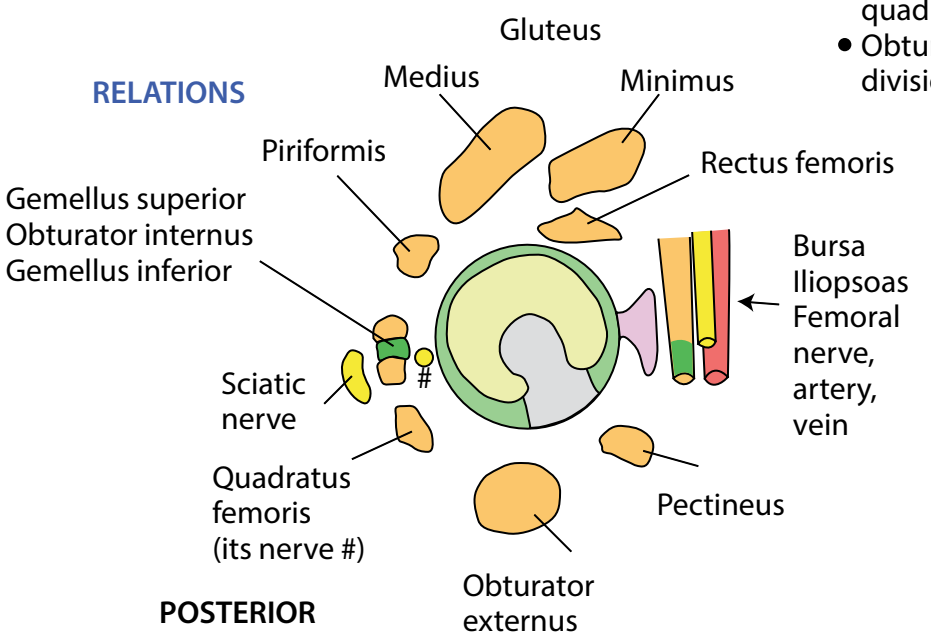
BURSAE

- Psoas may communicate into hip joint
- Trochanteric
- Ischial

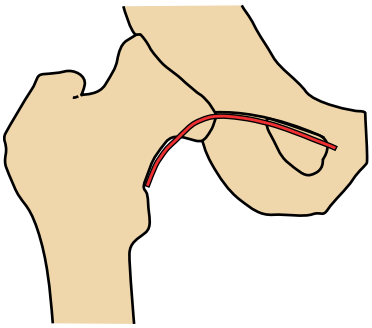
NERVES

- Femoral (because of rectus femoris)
- Sciatic (because of quadratus femoris)
- Obturator - posterior division

RELATIONS



LOWER LIMB: SURFACE AND APPLIED ANATOMY

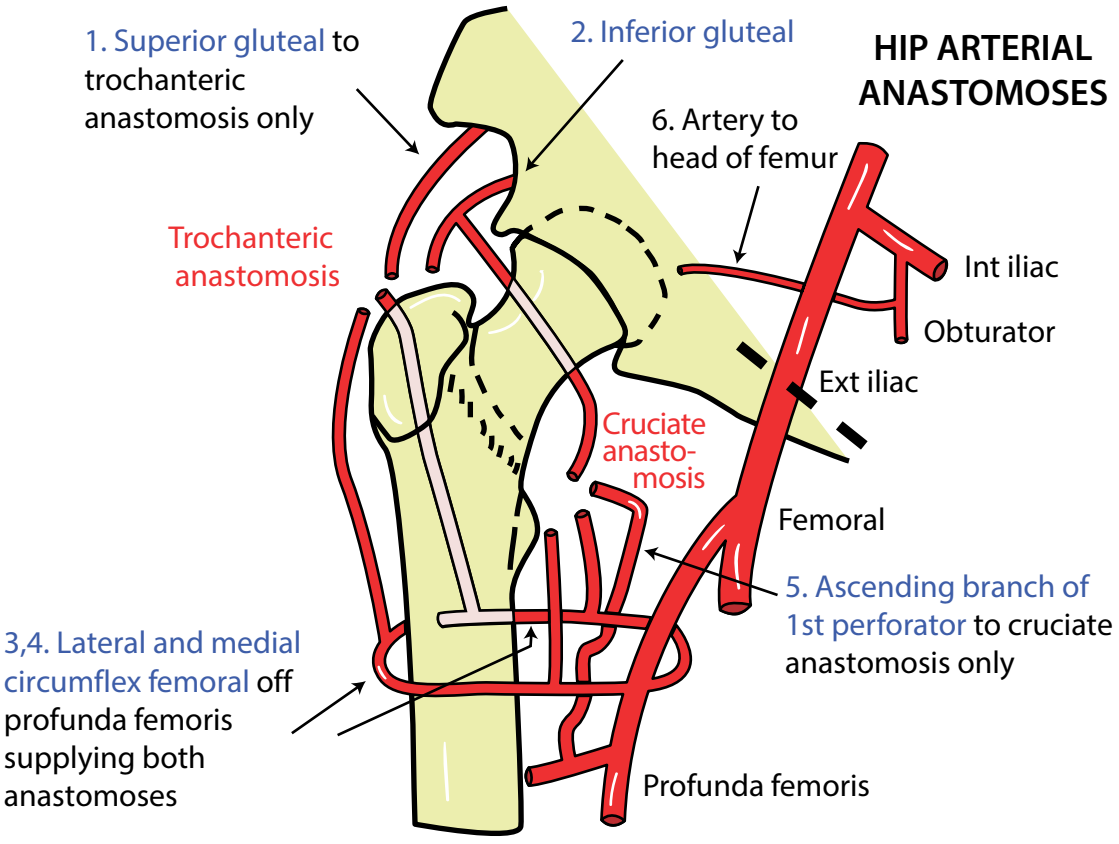


SHENTON'S LINE

Shenton's Line is a useful observation when looking at a radiograph of a pelvis/hip. In the normal appearances this line is smooth and unbroken

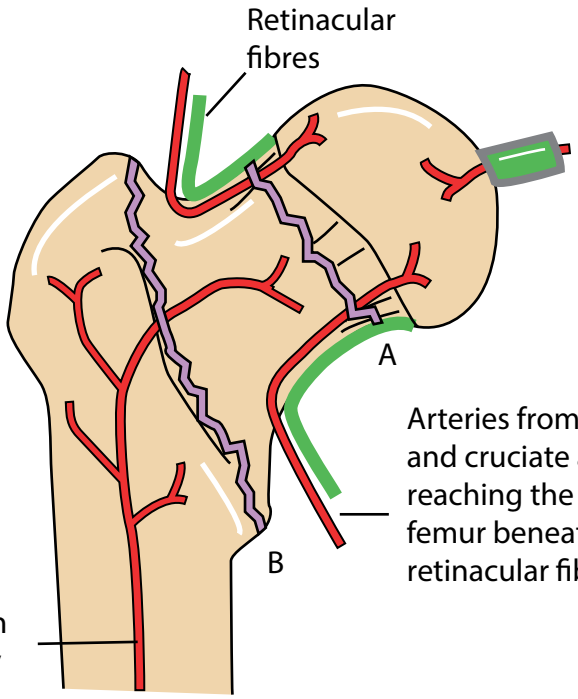
Note: When measuring to see if there is shortening of the lower limb it can be measured from the umbilicus to the medial malleolus. This may give an APPARENT shortening when the two sides are compared. However, only if the legs are measured from the anterior superior iliac spine to the medial malleolus will TRUE shortening be detected.

HIP ARTERIAL ANASTOMOSES

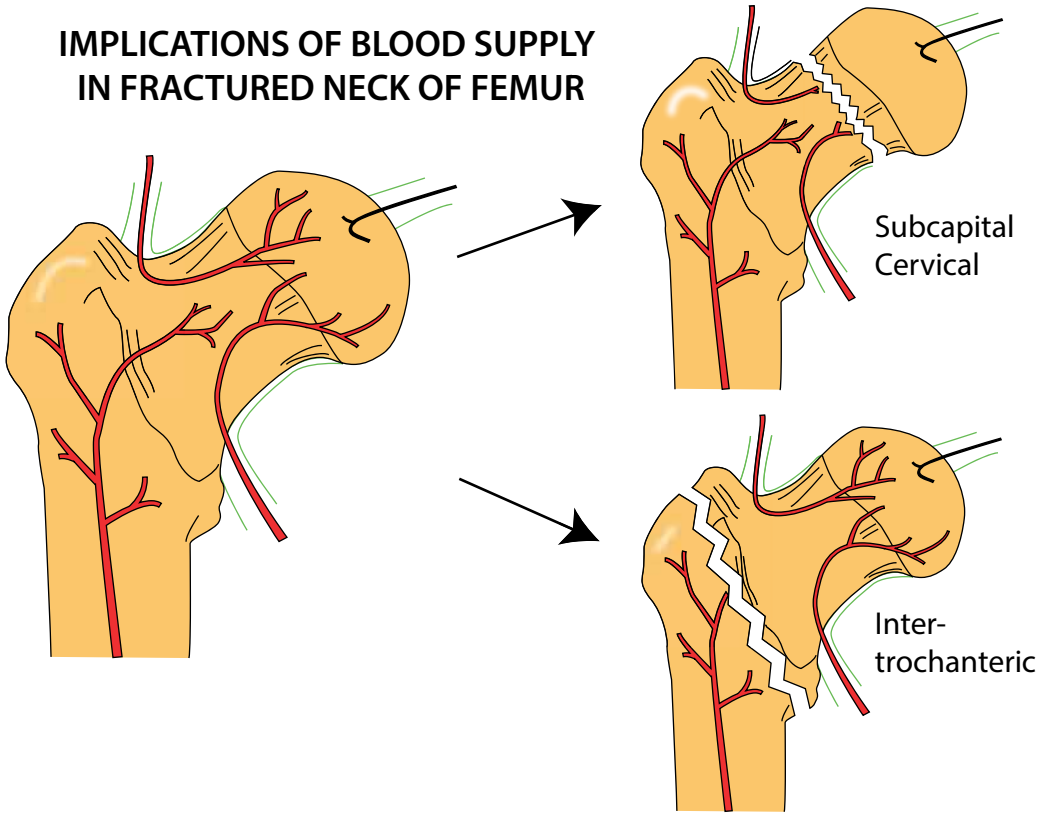


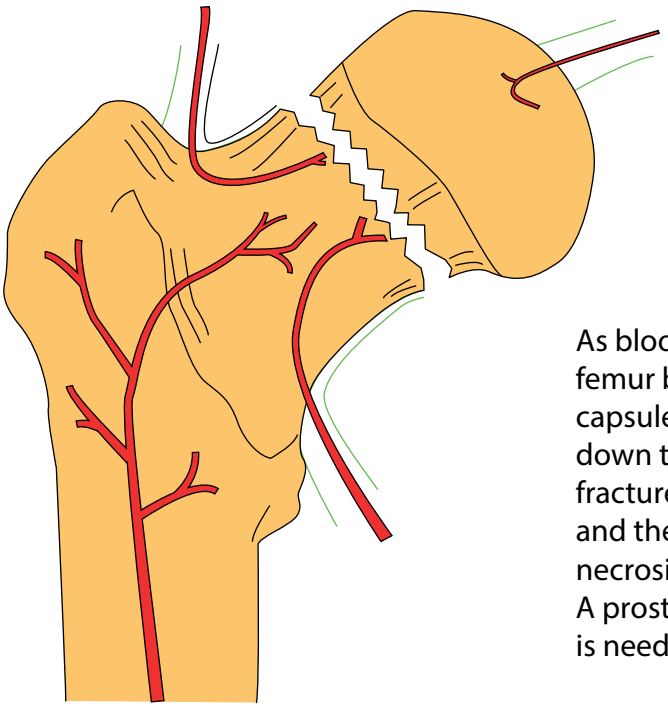
ARTERIAL SUPPLY TO HIP JOINT

Fracture lines.
A: Subcapital destroying virtually all supply to head of femur. Note that the vessels run beneath the retinacular fibres.
B: Intertrochanteric fracture which spares the majority of arterial supply to the head of the femur



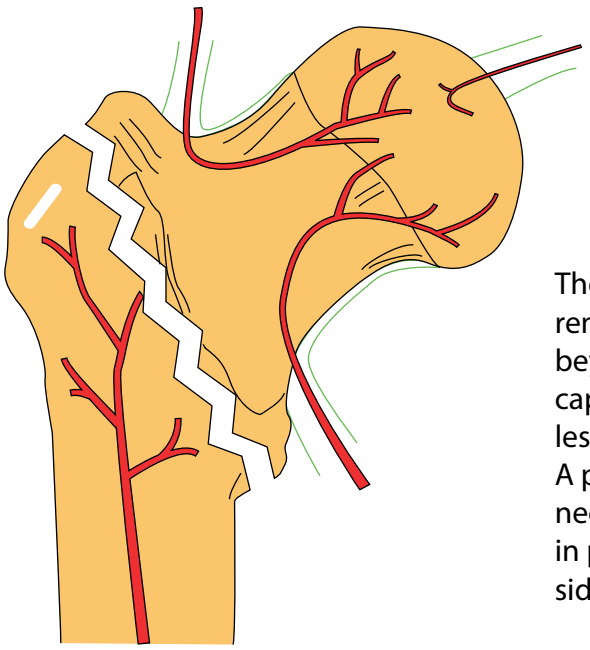
IMPLICATIONS OF BLOOD SUPPLY IN FRACTURED NECK OF FEMUR





SUBCAPITAL/ UPPER CERVICAL FRACTURED NECK OF FEMUR

As blood enters the head of the femur by passing beneath the capsule of the joint which extends down the neck of the femur, in this fracture the vessels will be destroyed and the head will undergo avascular necrosis.
A prosthetic replacement of the head is needed.



INTERTROCHANTERIC FRACTURE OF THE NECK OF THE FEMUR

The blood supply in this fracture remains intact as the fracture is beyond the attachment of the capsule. Avascular necrosis is much less likely.
A pin can be placed through the neck and head of the femur and held in place with a plate down the lateral side of the femur.

FRACTURE OF NECK OF LEFT FEMUR
PHYSICAL SIGNS

Leg is externally rotated and shortened

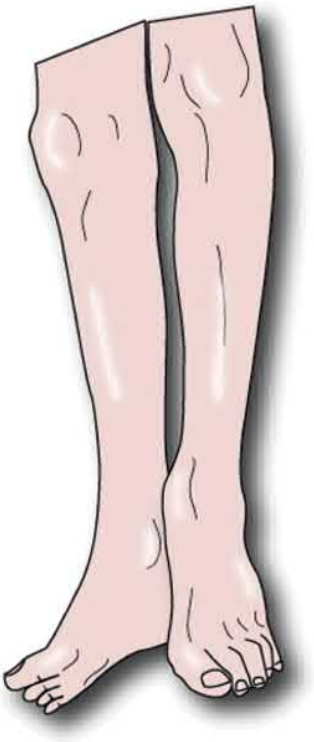
External rotation due to:

- Multitude of external rotator muscles
- Weight of leg
- Change in axis of psoas pull (see next image)

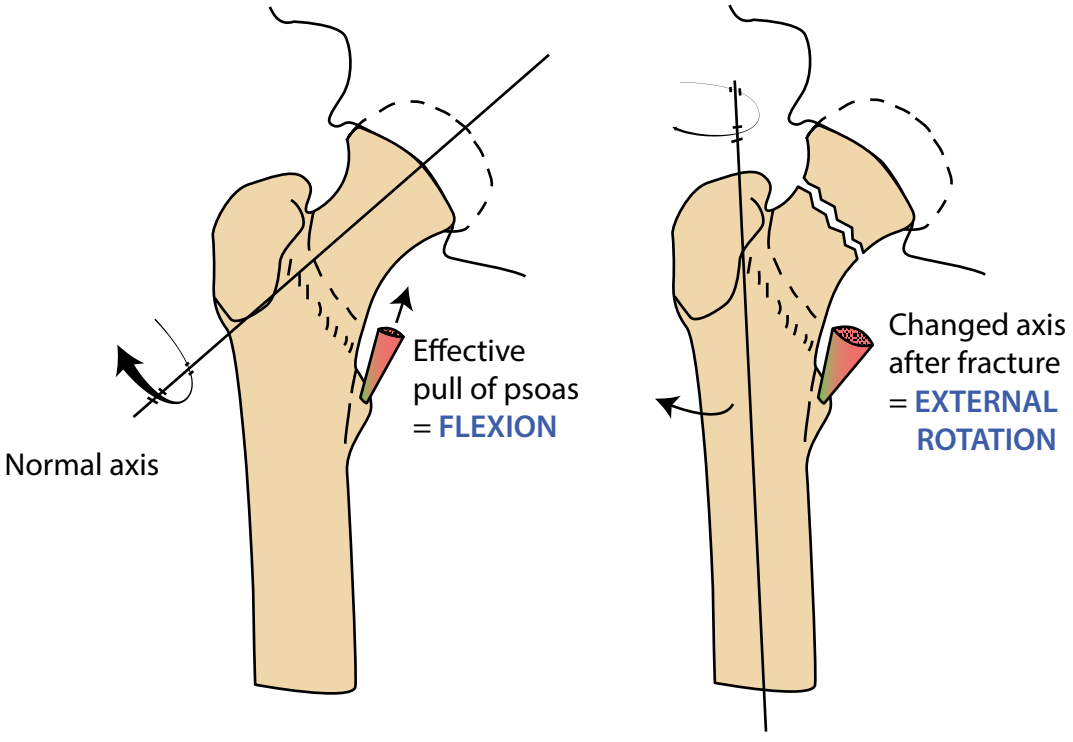
Shortening due to pull of:

All muscles from pelvis to leg

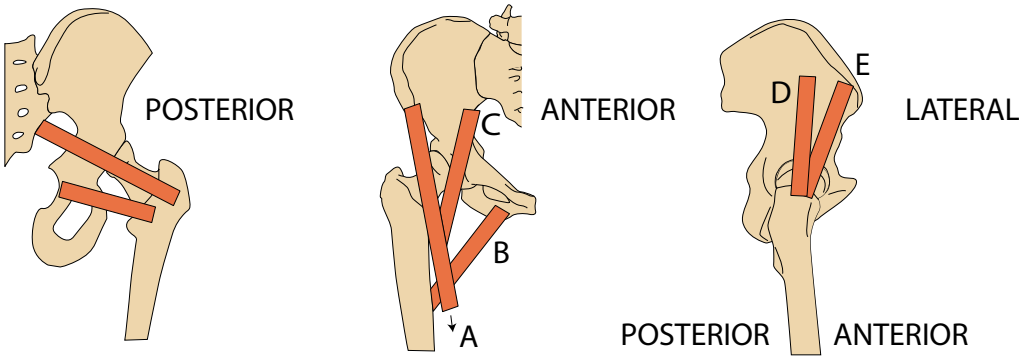
- Psoas/iliacus
- Rectus femoris
- Adductors
- Hamstrings
- Sartorius



CHANGE OF AXIS OF MOVEMENT AFTER FRACTURE OF NECK OF FEMUR



MOVEMENT AT THE HIP JOINT



EXTERNAL ROTATION
- Piriformis
- Gemelli
- Obturator externus
- Obturator internus
- Quadratus femoris
- Gluteus maximus (+ extension)
- Sartorius (A) (+ flexion)

ADDUCTION ONLY (B)
- Adductors: longus, brevis, magnus
- Gracilis
- (Pectineus)

FLEXION (C)
- Psoas and iliacus
- Rectus femoris

EXTENSION
- Hamstrings

ABDUCTION ONLY (D)
- Gluteus medius and minimus (posterior fibres)

INTERNAL ROTATION (E)
- Gluteus medius and minimus (anterior fibres)

HIP JOINT MOVEMENTS

Abduction
Gluteus medius, gluteus minimus, tensor fasciae latae

Adduction
Adductors brevis, longus, magnus (pectineus, gracilis, iliopsoas)

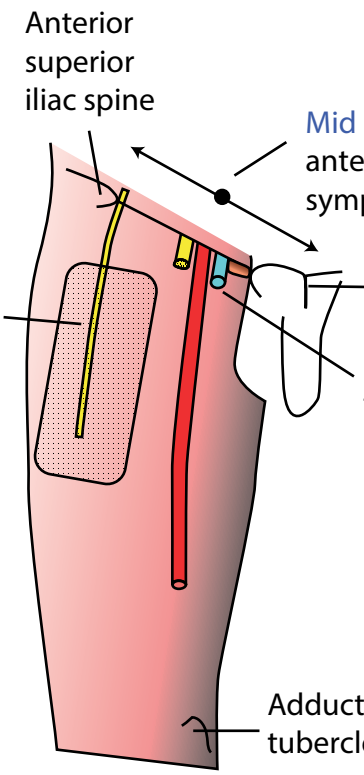
Flexion
Psoas, iliacius, rectus femoris, sartorius, (pectineus, tensor fasciae latae). Note soft tissue limitation

Extension
Gluteus maximus, semitendinosus, semimembranosus, adductor magnus, long head biceps femoris. Note, limited by capsule and ligaments

External rotation
Gluteus maximus, piriformis, obturators internus and externus, gemelli, quadratus femoris

Internal rotation
Anterior fibres of gluteus medius and minimus

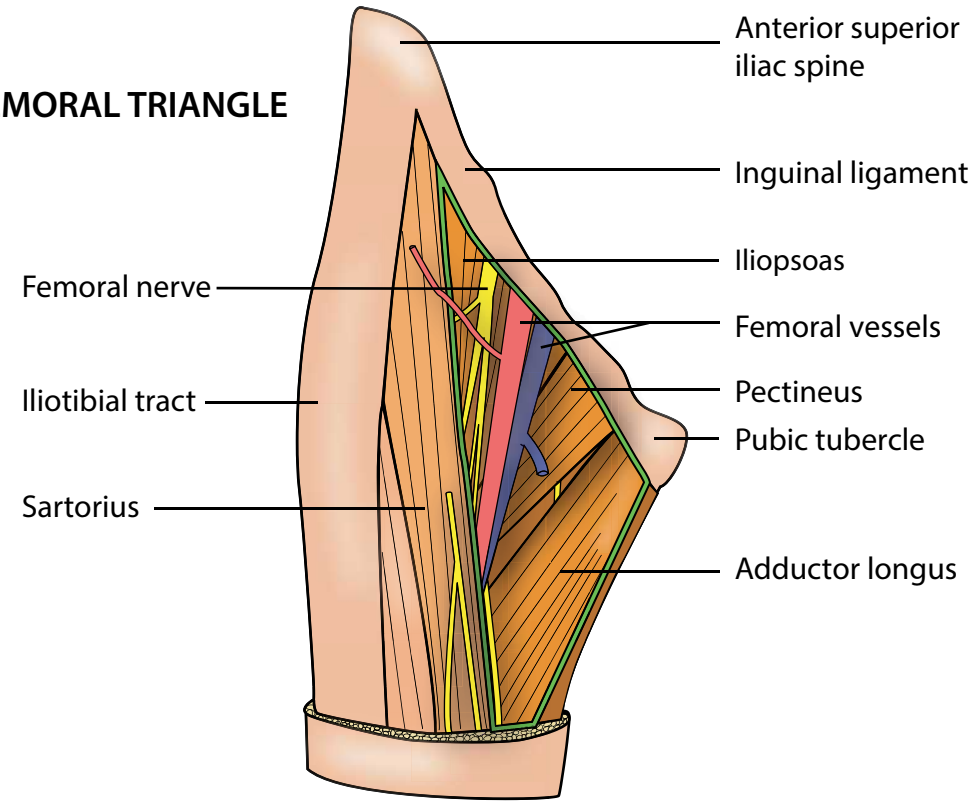
FEMORAL ARTERY IN THIGH AND MERALGIA PARAESTHETICA



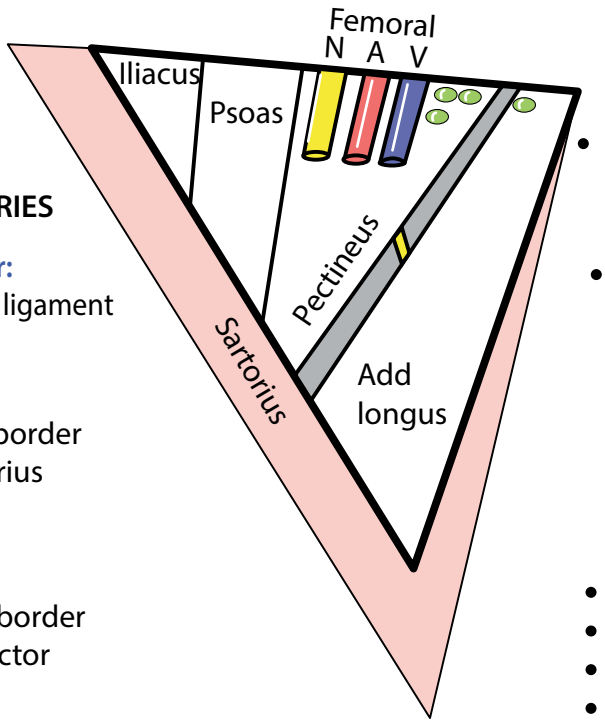
Distribution of meralgia paraesthetica which is an irritation in the distribution of the lateral femoral cutaneous nerve of the thigh (L2,3). The paraesthesia is felt lateral to the femoral artery

The femoral artery lies 2/3 along a line from the mid inguinal point to the adductor tubercle. It then goes deep to enter the popliteal fossa via the adductor hiatus

FEMORAL TRIANGLE



FEMORAL TRIANGLE



BOUNDARIES

Superior:
- Inguinal ligament

Lateral:
- Medial border of sartorius

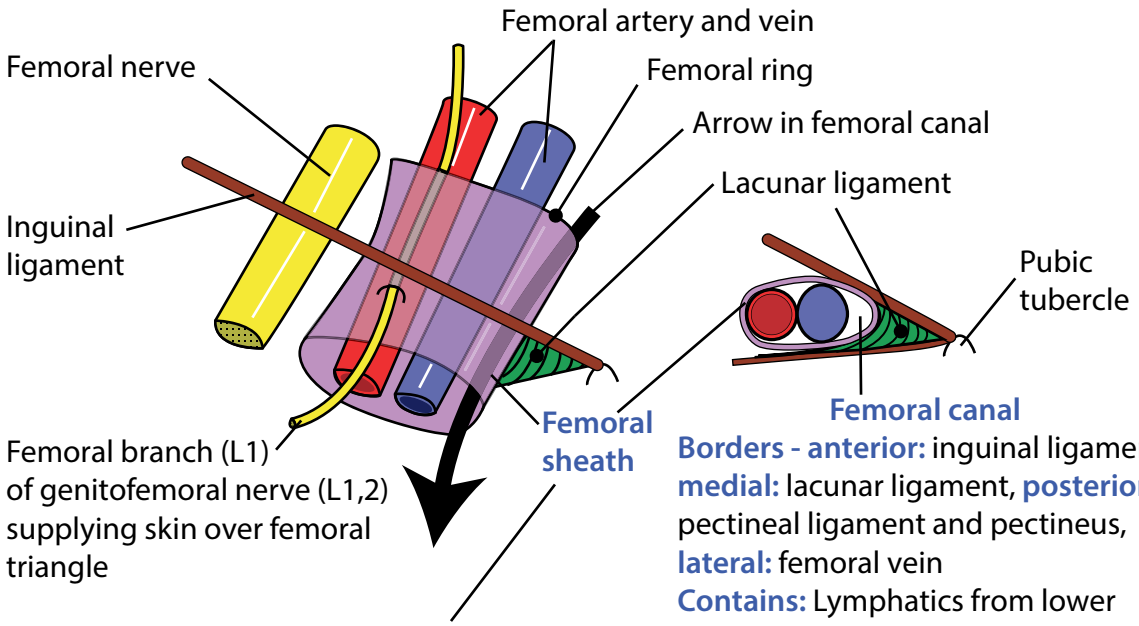
Medial:
- **Medial** border of adductor longus

Roof:
- Fascia lata

Floor:
- Muscles as shown with adductor brevis just showing. It has the anterior division of the obturator nerve on its surface

Contains:
- Femoral nerve
- Femoral artery
- Femoral vein
- Deep inguinal nodes

RIGHT FEMORAL CANAL, SHEATH AND RING

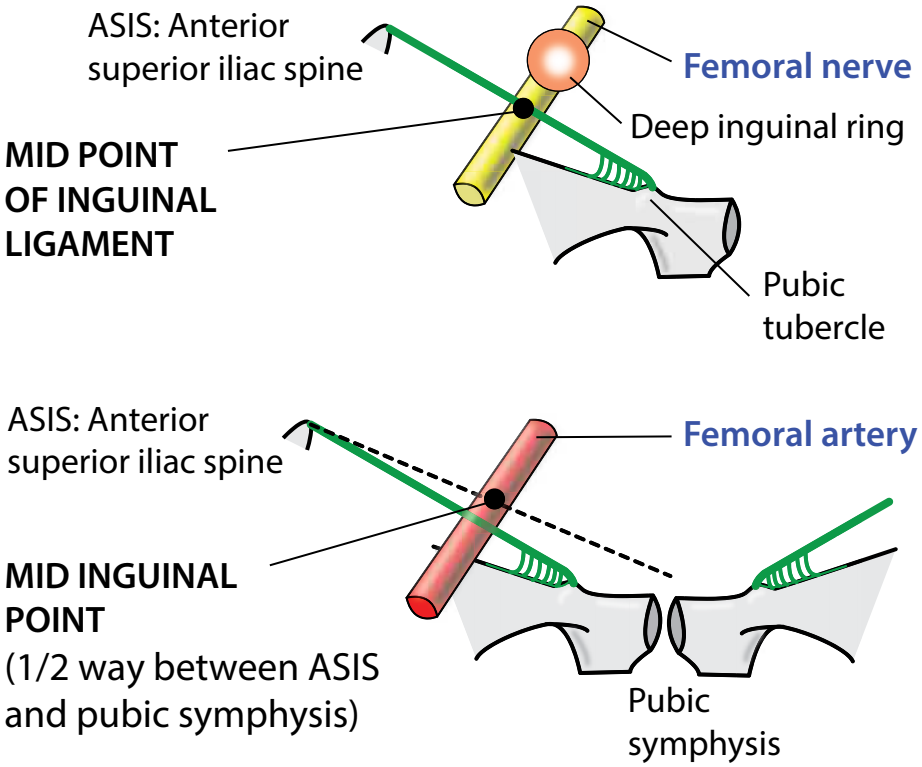


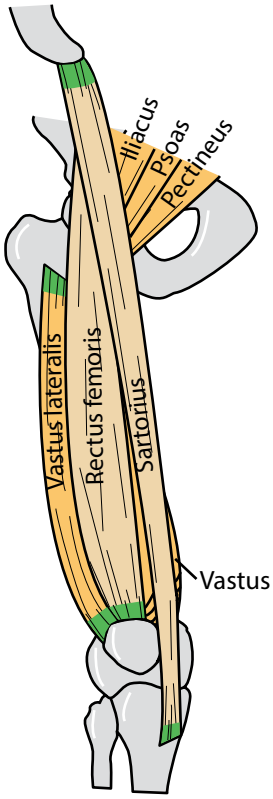
Femoral canal

Borders - anterior: inguinal ligament, **medial:** lacunar ligament, **posterior:** pectineal ligament and pectineus, **lateral:** femoral vein

Contains: Lymphatics from lower limb and Cloquet's lymph node

Allows: Expansion of femoral vein when venous return is increased





ANTERIOR THIGH AND HIP FLEXORS

Note on Psoas/iliacus:
Despite some opinions, experiments show that these muscles act purely as flexors of the hip and not rotators. However, in the presence of a fractured neck of femur the line of axis changes and they produce external rotation

THE "3 WATERSHED MUSCLES" WAY OF REMEMBERING THIGH MUSCLES

The 3 muscles with dual nerve supply are interposed between the three groups of muscles in the thigh. If you can recall these 3 then the groups are easily remembered

Anterior group (FEMORAL NERVE)
sartorius, rectus femoris, 3 vasti

→ Pectineus
(FEMORAL AND OBTURATOR NERVES)

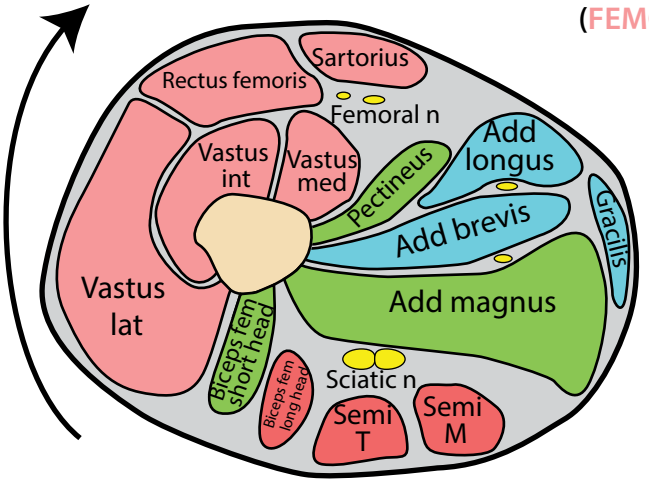
→ Adductor group:
(OBTURATOR NERVE)
adductor longus, brevis,gracilis

→ Adductor magnus - adductor portion
(OBTURATOR NERVE)
Adductor magnus hamstring portion
(TIBIAL PORTION OF SCIATIC NERVE)

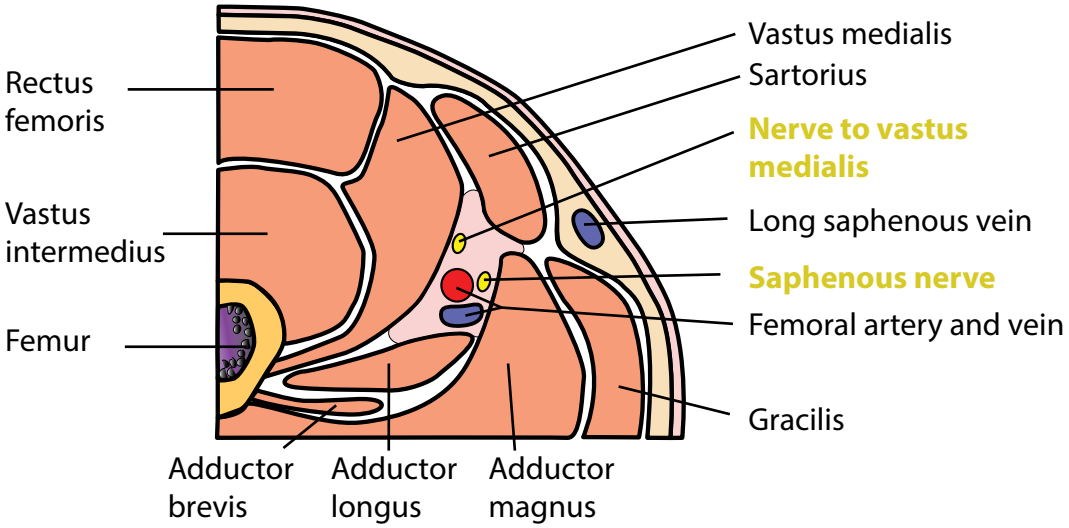
→ Posterior/hamstrings group:
(TIBIAL PORTION OF SCIATIC NERVE)
semitendinosus, semimembranosus

→ Biceps femoris - long head
(TIBIAL PORTION OF SCIATIC NERVE)
Biceps femoris - short head
(COMMON FIBULAR NERVE)

→ Anterior group (FEMORAL NERVE)
sartorius, rectus femoris, 3 vasti

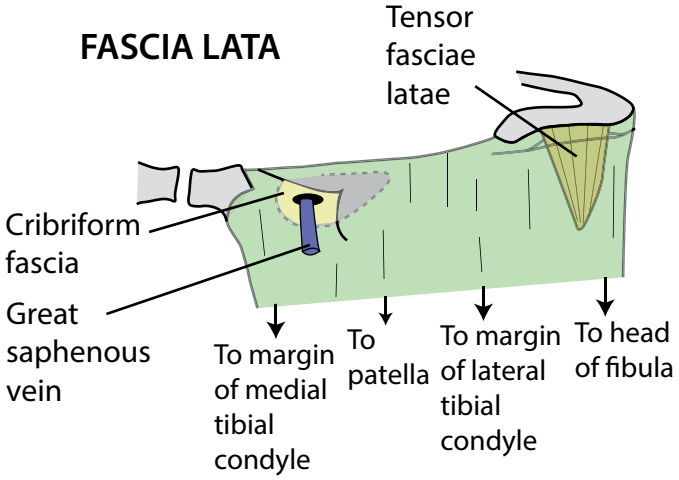


RIGHT ADDUCTOR (SUBSARTORIAL/HUNTER'S) CANAL (viewed from below)



Apex of femoral triangle to adductor hiatus
Borders - **lateral:** vastus medialis, **medial:** adductor longus superiorly and adductor magnus inferiorly, **roof:** sartorius. **Contains:** Femoral artery and vein; saphenous nerve; nerve to vastus medialis

FASCIA LATA

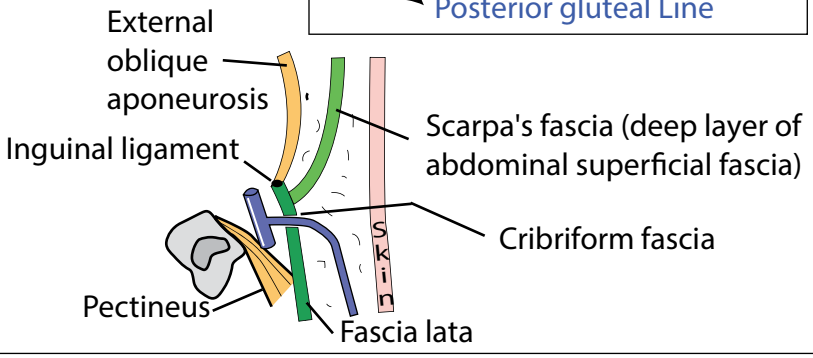


ATTACHMENTS OF FASCIA LATA

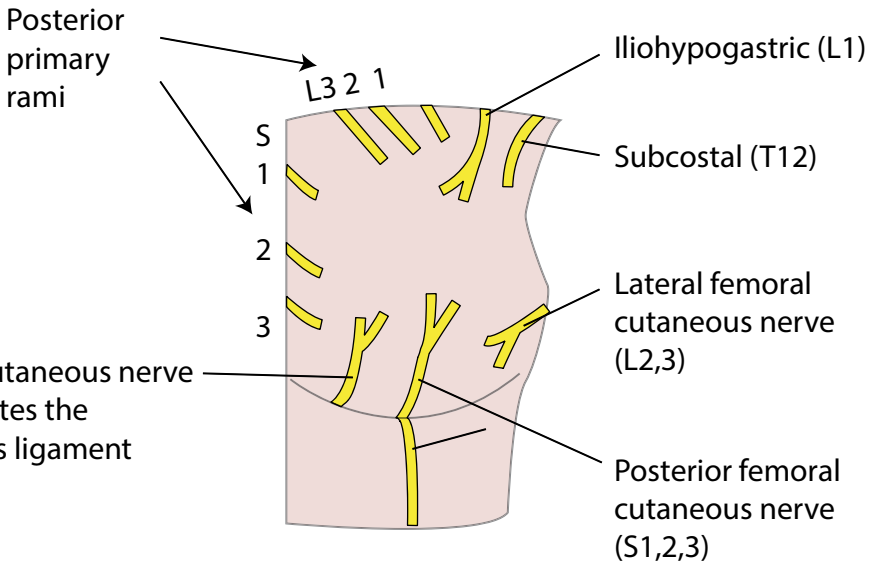
START	END
Pubic tubercle	Along pectineal line
Inguinal ligament	Below pubic tubercle
ASIS	Body of pubis
Outer margin iliac crest	Ischiopubic ramus
Iliac tubercle	Ischial tuberosity
Posterior gluteal Line	Sacrotuberous lig.

ILIOTIBIAL TRACT

Thickening of fascia lata over greater trochanter after insertion of tensor fasciae latae and gluteus maximus. Attaches to anterior surface of lateral tibial condyle.It maintains knee locked



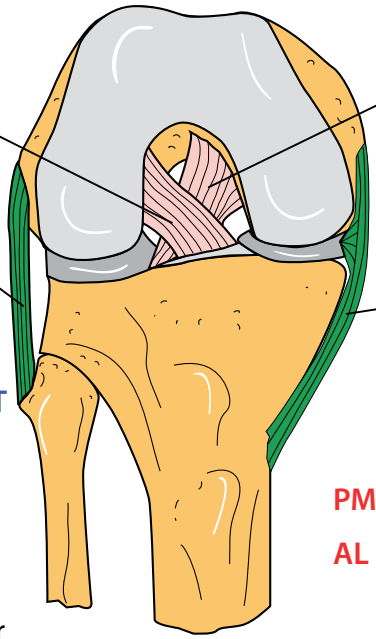
CUTANEOUS NERVE SUPPLY OF BUTTOCKS



NOTE: Pain may be referred between pelvis (autonomics S2,3) and the posterior femoral cutaneous nerve (S2,3)

2.3 Knee and Popliteal Fossa

ANTERIOR VIEW OF RIGHT KNEE



Anterior cruciate ligament - tight in extension, stops femur slipping backwards

Cordlike **lateral collateral ligament** - not attached to lateral meniscus

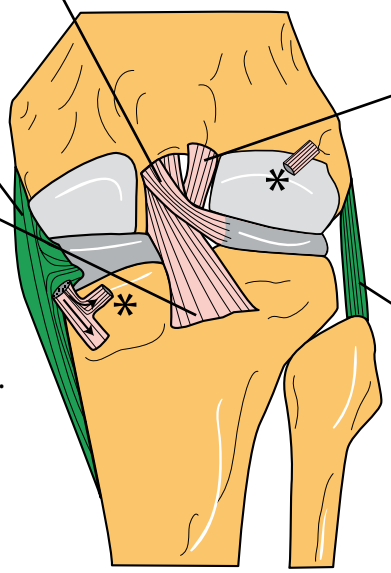
Posterior cruciate ligament - stops femur slipping forwards on tibia

Broad medial collateral ligament - attached to medial meniscus

ANTERIOR CRUCIATE LIGAMENT
From: Anterolateral tibia
To: Posterior on medial side of lateral femoral condyle
Limits: Extension and anterior draw and is taut on locking
Test: Pull tibia forwards on femur

PM - Posterior goes medial
AL - Anterior goes lateral

POSTERIOR VIEW OF RIGHT KNEE



Broad **medial collateral ligament** - attached to medial meniscus

Posterior meniscofemoral ligament Attached to medial femoral condyle

Posterior cruciate ligament - stops femur slipping forwards on tibia

Anterior cruciate ligament - tight in extension, stops femur slipping backwards

Cordlike **lateral collateral ligament** - not attached to lateral meniscus

POSTERIOR CRUCIATE LIGAMENT
From: Posteromedial tibia
To: Anterior on lateral side of medial femoral condyle
Limits: Posterior slide of tibia on femur.
Used: Down stairs and on hills
Test: Push tibia back on femur

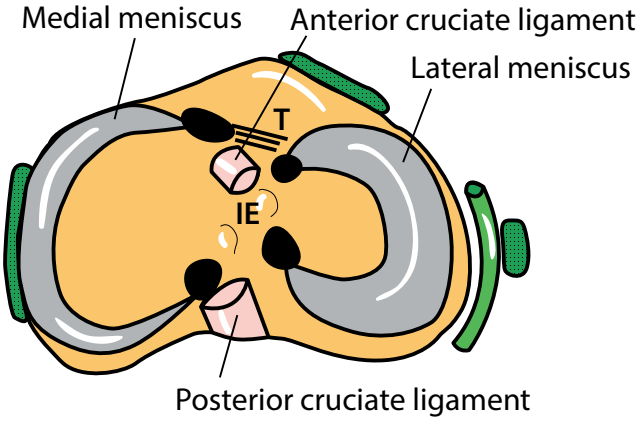
* **Oblique popliteal ligament,** a superficial structure, is one of the attachments of the semimembranosus tendon

PM - Posterior goes medial
AL - Anterior goes lateral

STRUCTURES ON RIGHT TIBIAL PLATEAU

T = Transverse ligament
IE = Intercondylar eminence with medial and lateral intercondylar tubercles

MENISCI
Liable to tears when flexed knee is twisted.
Function: transfers forces, keep bones together, helps locking

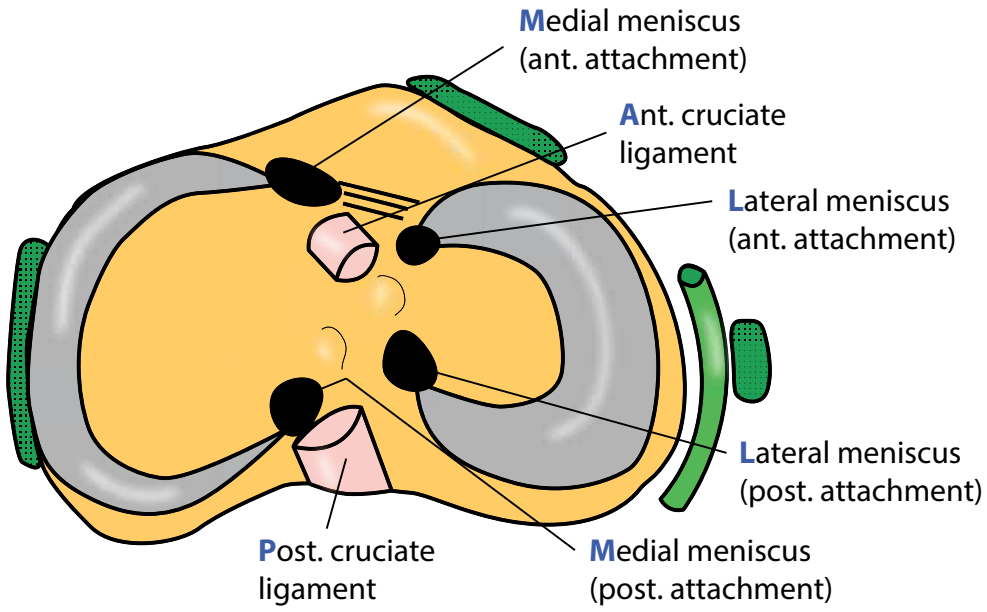


MEDIAL MENISCUS
- Wider "C"
- Medial lip slopes up
- Attaches as shown but also to medial collateral ligament
- More liable to damage than lateral meniscus

LATERAL MENISCUS
- Smaller, tighter "C"
- Lateral lip slopes down
- Not attached to lateral collateral ligament
- Attached as shown
- Lightly attached to popliteus and is retracted by it on flexion

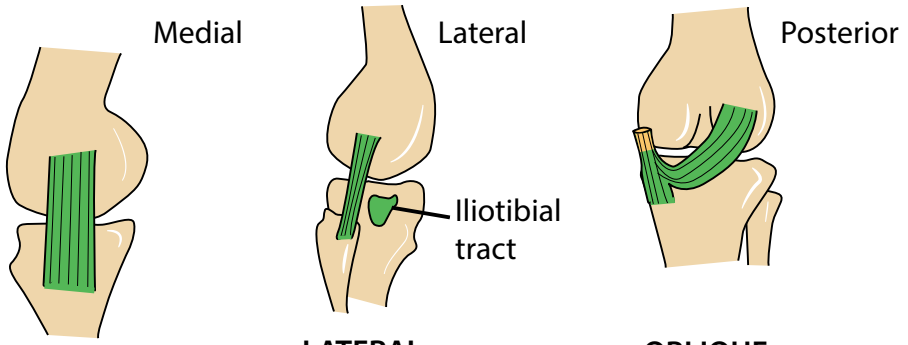
ORDER OF STRUCTURES ON RIGHT TIBIAL PLATEAU (Anterior to posterior)

M
A
L
L
M
P



Note: The coronary ligaments of the knee are parts of the joint capsule that connect the lower edges of the menisci to the edges of the tibial plateau

SUMMARY OF LIGAMENTS OF RIGHT KNEE



MEDIAL COLLATERAL

- Broad, long, thick, strong
- Attached to capsule and medial meniscus
- Limits full extension and thus aids locking

LATERAL COLLATERAL

- Thick, cordlike.
- Not attached to joint structures.
- Limits full extension and thus aids locking

OBLIQUE POPLITEAL

- Upward extension of semimembranosus tendon.
- Limits extension and thus aids knee locking

NOTE

- Knee is largest joint in body
- It is a modified hinge joint
- The line of the body weight is anterior to the knee

BLOOD, NERVE SUPPLY AND MOVEMENTS OF KNEE JOINT

BLOOD SUPPLY

Genicular arteries from popliteal:

- Superior (medial and lateral)
- Middle
- Inferior (medial and lateral)

Femoral gives: Descending branch from profunda

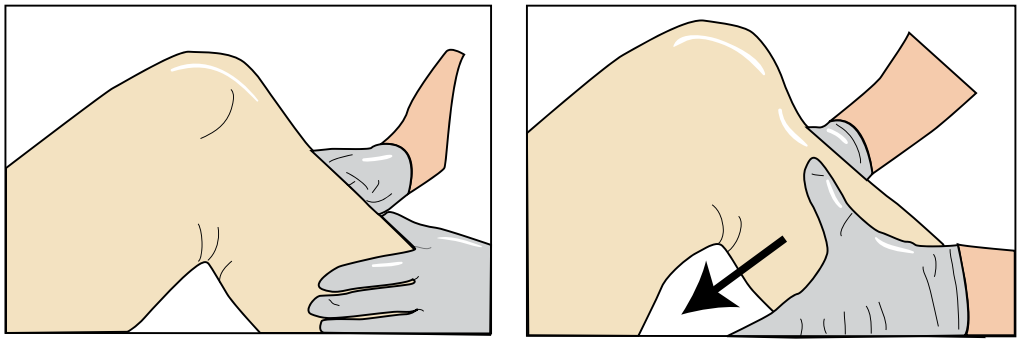
NERVES

Posterior division of obturator
Femoral
Sciatic (both parts)

MOVEMENTS

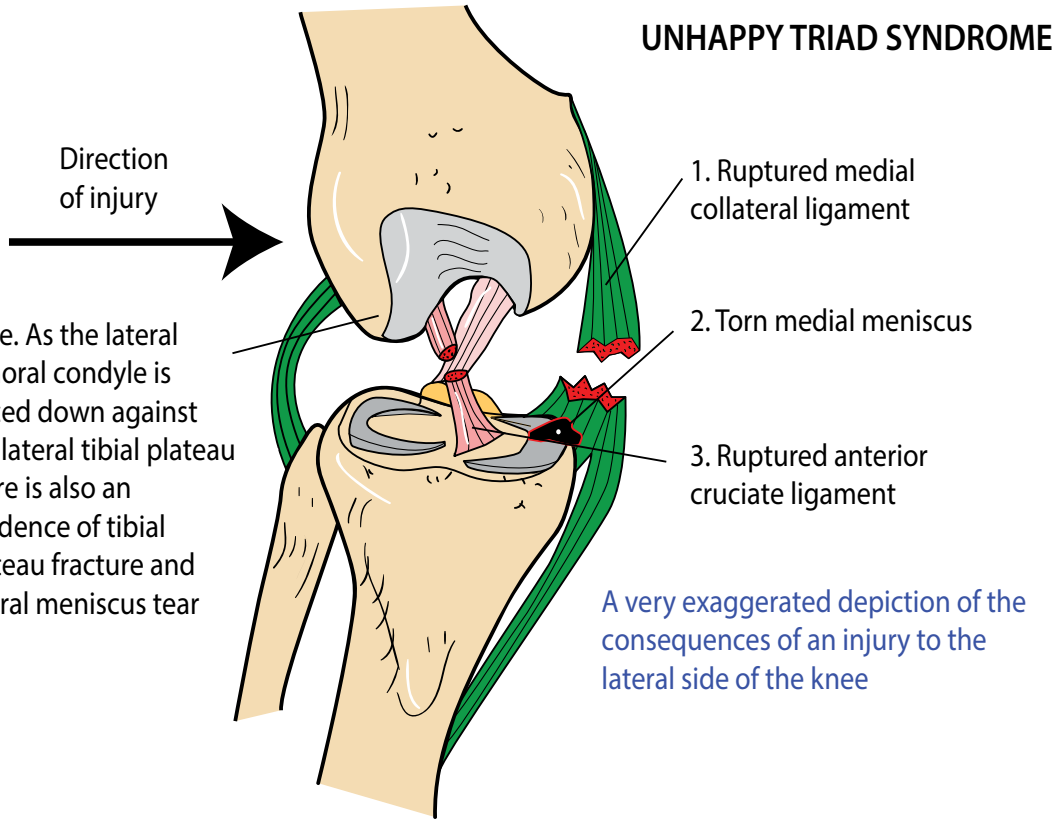
Flexion: Semimembranosus, semitendinosus, biceps, gracilis, sartorius (gastrocnemius, plantaris, popliteus)
Extension: Quadriceps femoris, iliotibial tract (gluteus maximus, tensor fasciae latae)
Internal rotation(with knee flexed): Semimembranosus, semitendinosus, gracilis, sartorius
External rotation(with knee flexed): Biceps
Unlocking: Popliteus

DRAWER TEST



DRAWER TEST
Positive posterior drawer test showing a ruptured posterior cruciate ligament.
BUT beware - POSTERIOR SAG SIGN: if the dip below the patella is not noticed this might appear as a false positive anterior drawer test when the tibia is pulled anteriorly

UNHAPPY TRIAD SYNDROME

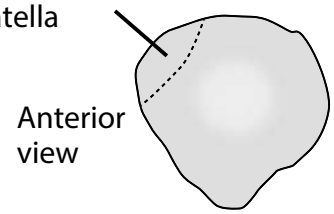


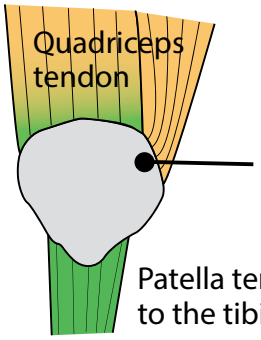
Note. As the lateral femoral condyle is forced down against the lateral tibial plateau there is also an incidence of tibial plateau fracture and lateral meniscus tear

A very exaggerated depiction of the consequences of an injury to the lateral side of the knee

RIGHT PATELLA

Upper lateral part is site of bipartite patella





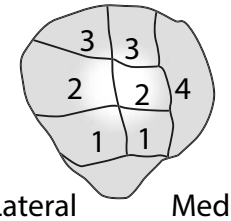
Posterior view

Largest sesamoid bone in body. Mobile from side to side

Lateral/posterior surface is: Larger, longer, more steeply sloped

Patella tendon attaches to the tibial tubercle

ARTICULATION WITH FEMUR

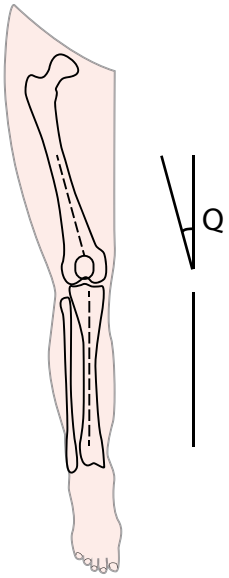


1. In extension
2. In slight flexion
3. In flexion
4. In full flexion

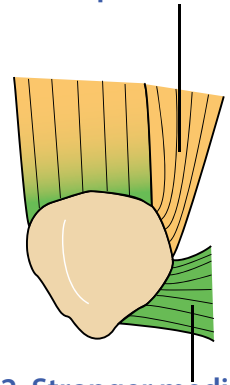
OSSIFICATION

Several centres between 3 and 6 years that fuse at puberty (they appear as child starts running). Sometimes a separate centre superior/lateral at 6 years - fuses at puberty

THE Q ANGLE AND PATELLA DISLOCATION

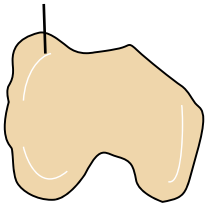


1. Insertion of lower fibres of vastus medialis into medial side of patella



2. Stronger medial retinacular fibres of knee capsule

3. More anteriorly protuberant lateral condyle of lower femur. Note that lateral condyle is smaller than medial one but it protrudes further anteriorly



Deviation from the vertical (the tibia) to a line along the femur (pull of quadriceps). Wider the pelvis, the greater the **Q angle** (greater in females).
Offset tends to pull patella laterally. 3 factors shown here help to avoid dislocation

PHYSIOLOGICAL LOCKING OF KNEE

LOCKING

Full extension → Taut anterior cruciate → No further symmetrical extension → Medial femoral condyle moves back - lateral condyle moves forwards

↓

Femur internally rotates on tibia on axis of anterior cruciate ligament

← Medial/lateral collateral and oblique popliteal ligaments tighten

← Tensor fasciae latae and gluteus maximus tighten iliotibial tract

↓

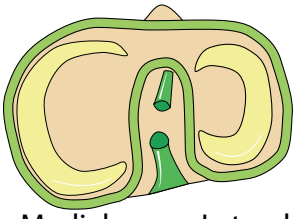
Knee "hyperextends" and locks

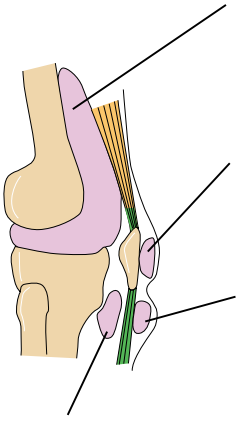
UNLOCKING

Popliteus externally rotates femur on tibia → Locked ligaments loosen → Hamstrings can then flex knee

BURSAE AND SYNOVIUM OF KNEE

Tibial plateau showing attachment of synovium to its edges. The cruciate ligaments lie outside it but the menisci within it





Suprapatellar bursa. Extension of synovium of knee joint

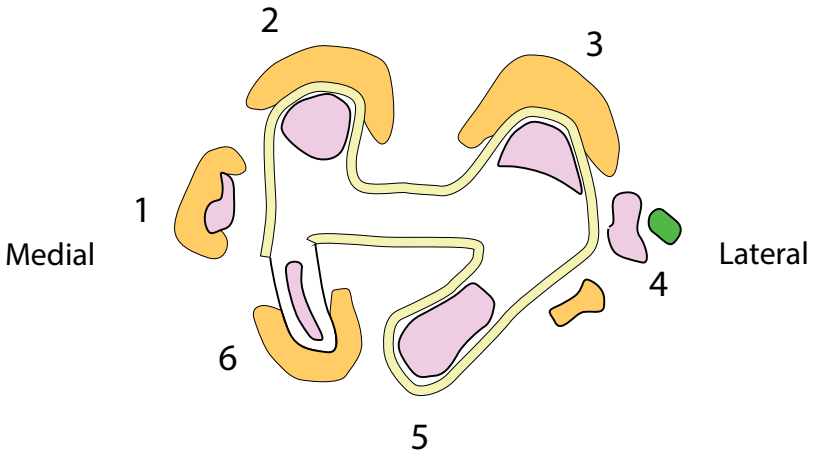
Prepatellar bursa (Housemaid's)

Superficial infrapatellar bursa (Clergyman's)

Deep infrapatellar bursa

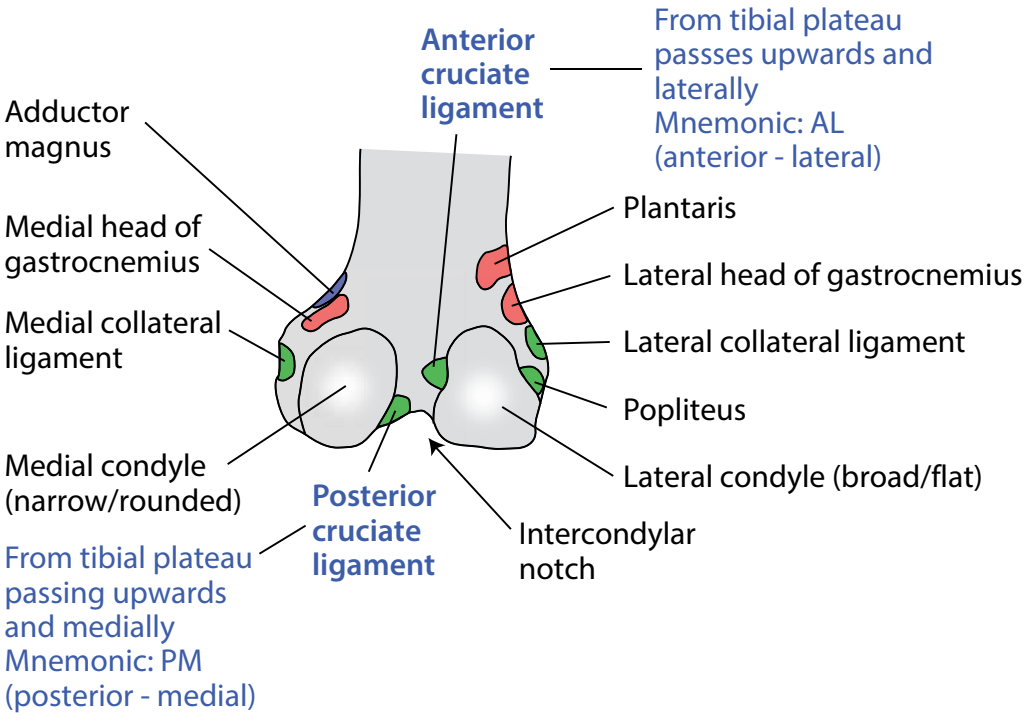
Synovium lines the inside of the capsule and is attached to the bony edges. It extends into the suprapatellar bursa

BURSAE AND SYNOVIUM OF KNEE

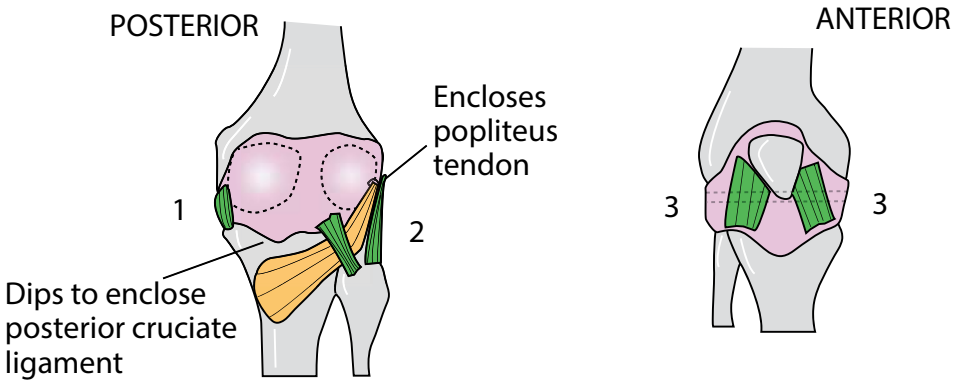


1. Under sartorius, gracilis, semitendinosus
2. Under medial head of gastrocnemius (often into joint)
3. Under lateral head of gastrocnemius (sometimes into joint)
4. Under lateral collateral ligament
5. Under popliteus (into joint)
6. Under semimembranosus

ATTACHMENTS TO LOWER POSTERIOR FEMUR



RIGHT KNEE JOINT CAPSULE



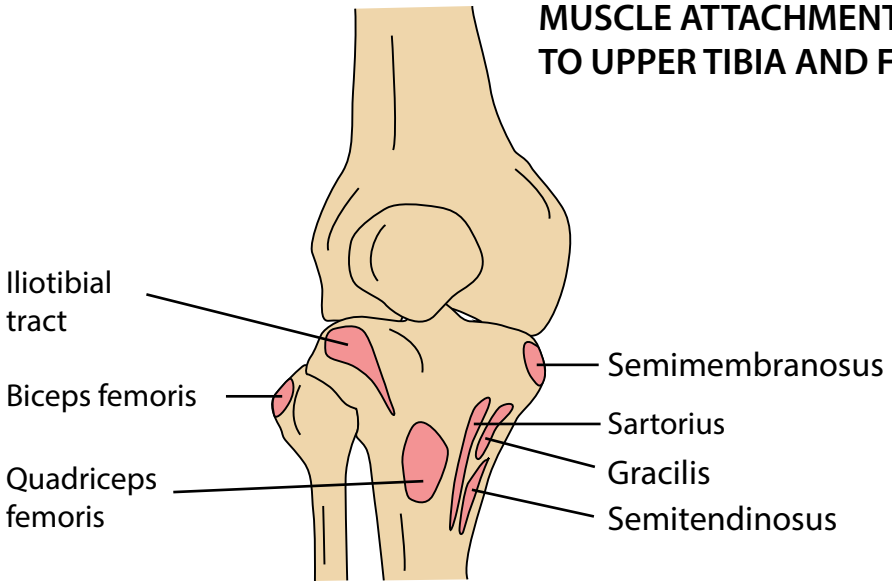
Capsule is attached to the bony margins of the tibia and femur. It has several thickenings shown below called internal ligaments.

1. Thickened medially to make the **Short Internal (medial) Ligament** which attaches to medial collateral ligament outside and to the medial meniscus inside as the **coronary ligaments.**

2. **Arcuate Popliteal Ligament.** This is Y shaped and the lateral part of it is often known as the **Short External (lateral) ligament.** Popliteus tendon passes medially to it.

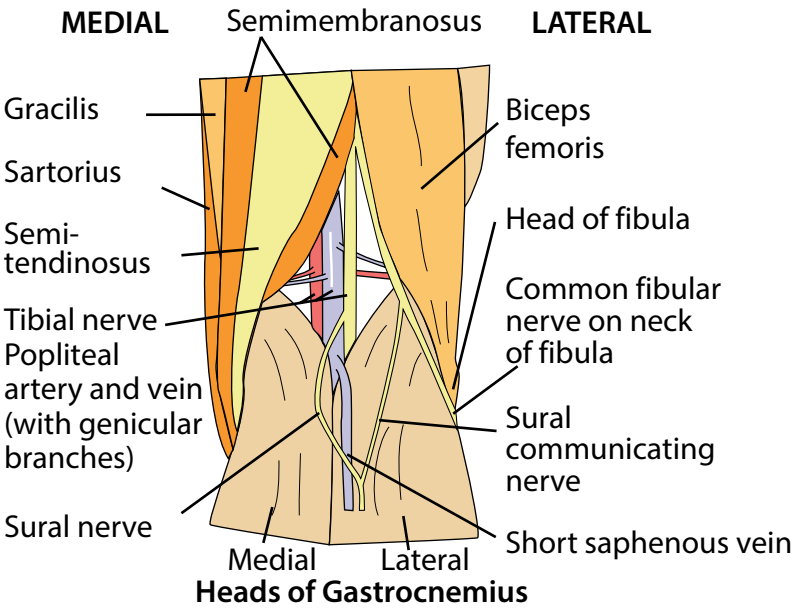
3. **Medial and lateral Patellar Retinacular Fibres.** These reinforce the capsule anteriorly. The medial ones are important as they help to prevent the patella dislocating laterally.

MUSCLE ATTACHMENTS TO UPPER TIBIA AND FIBULA



Order of attachment of tendons to the upper medial aspect of the tibia: "Say Grace Before Tea, Mum". Sartorius, gracilis, (bursa), semitendinosus, semimembranosus

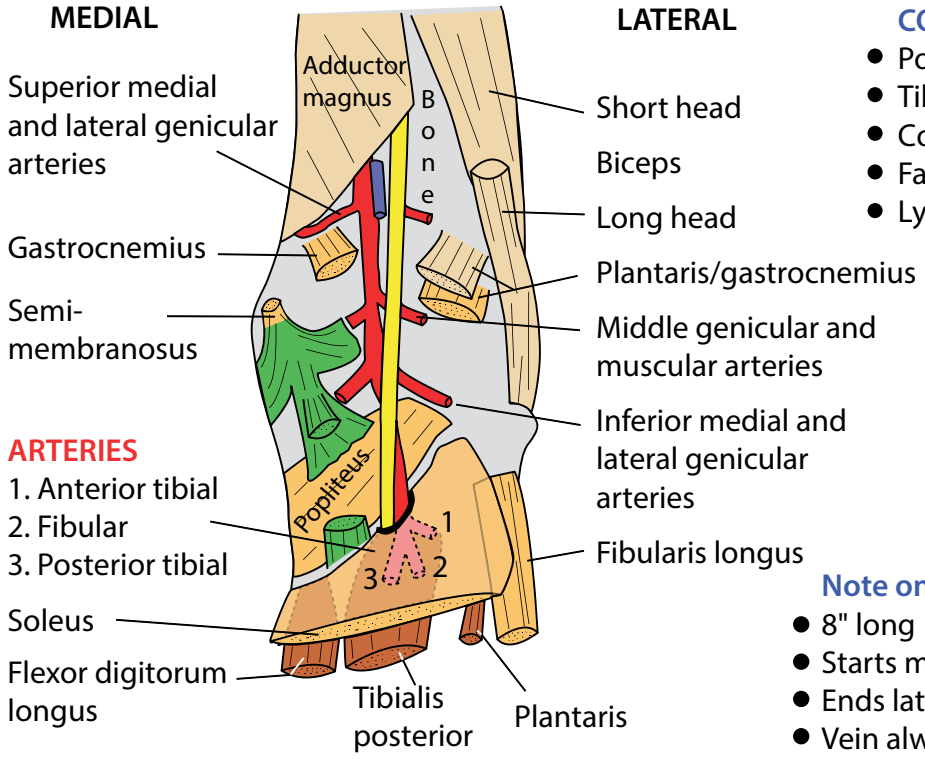
RIGHT POPLITEAL REGION



The diamond shaped popliteal fossa is bounded inferiorly by two heads of **gastrocnemius** and superiorly by **hamstrings**: **biceps femoris** (laterally) and **semitendinosus** and **semimembranosus** (medially).

The popliteal artery is the deepest (most anterior) structure and may be difficult to palpate. Anterior to it are the posterior surface of the femur, capsule of knee joint and popliteus.

RIGHT POPLITEAL FOSSA (DEEP DISSECTION)

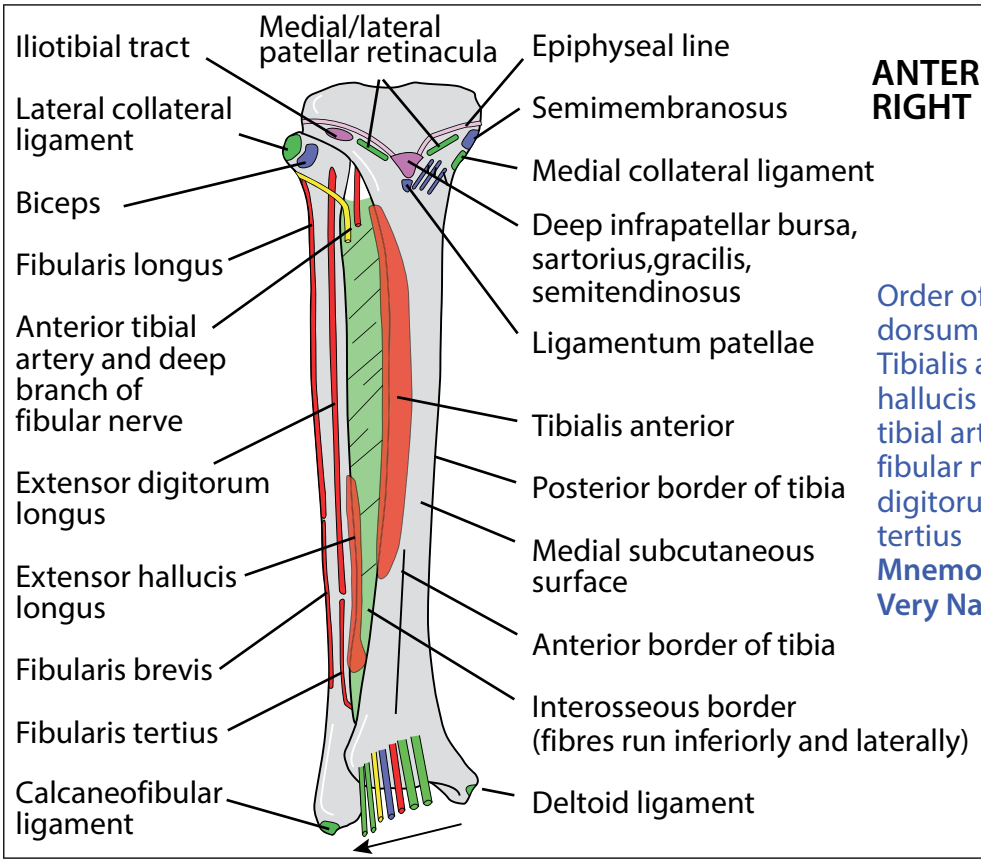


ARTERIES
1. Anterior tibial
2. Fibular
3. Posterior tibial

CONTENTS
- Popliteal artery and vein
- Tibial nerve
- Common fibular nerve
- Fat
- Lymph nodes

Note on popliteal artery
- 8" long
- Starts medial to tibial nerve
- Ends lateral to tibial nerve
- Vein always between the two

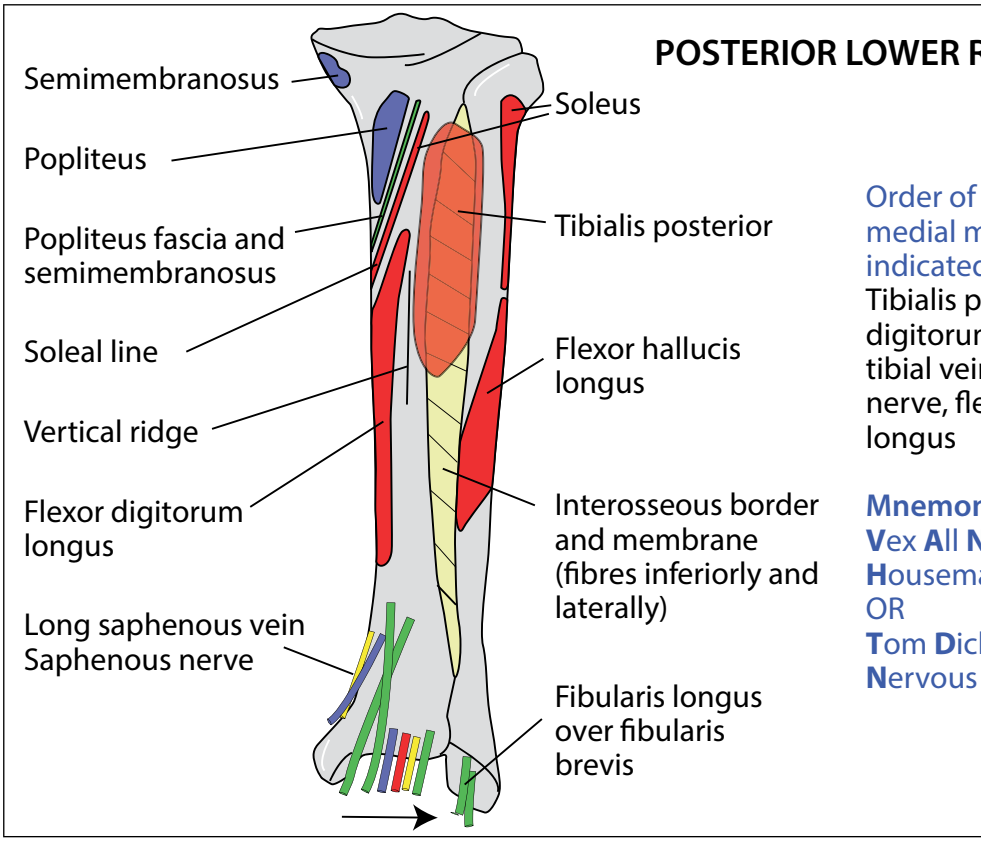
2.4 Lower Leg



ANTERIOR LOWER RIGHT LEG

Order of structures across dorsum of foot (arrow): Tibialis anterior, extensor hallucis longus, anterior tibial artery/vein, deep fibular nerve, extensor digitorum longus, fibularis tertius

Mnemonic: Timothy Has A Very Nasty Diseased Foot

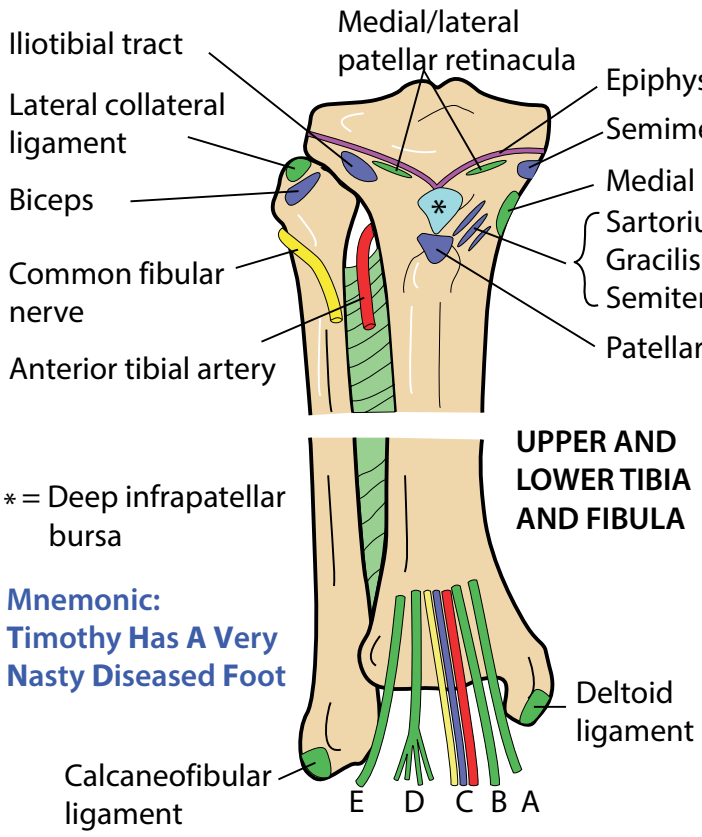


POSTERIOR LOWER RIGHT LEG

Order of structures behind medial malleolus as indicated by arrow: Tibialis posterior, flexor digitorum longus, posterior tibial vein and artery, tibial nerve, flexor hallucis longus

Mnemonic: **T**imothy **D**oth **V**ex **A**ll **N**ervous **H**ousemaids
OR
Tom **D**ick **A**nd **A** **V**ery **N**ervous **H**arry

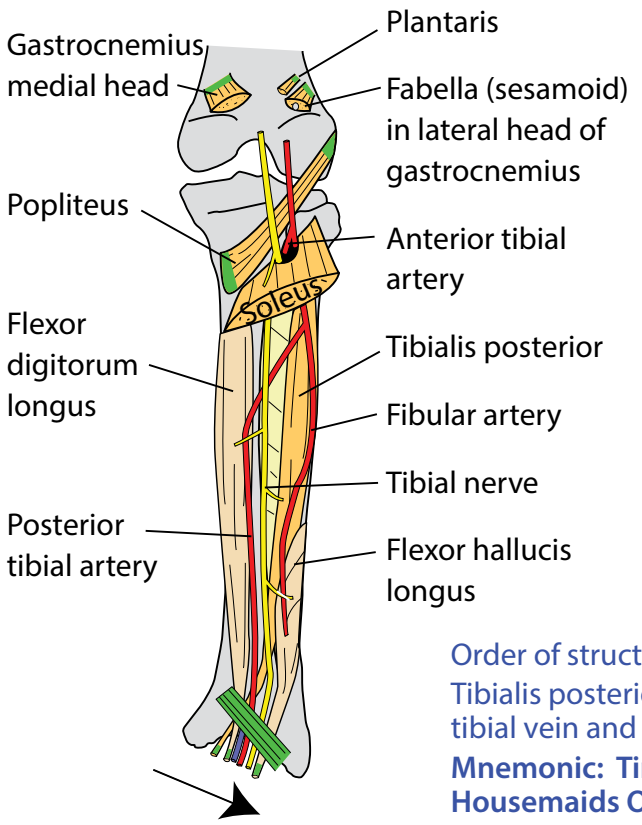
RELATIONS OF RIGHT TIBIA



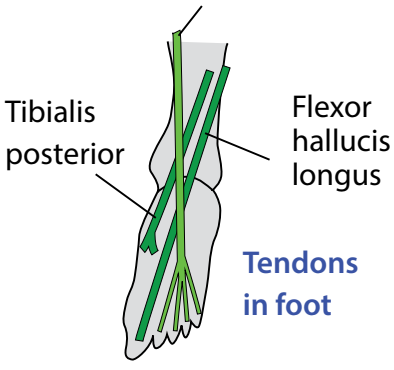
Mnemonic:
Timothy Has A Very Nasty Diseased Foot

Order of structures across anterior ankle from medial to lateral:
A = Tibialis anterior
B = Extensor hallucis longus
C = Anterior tibial artery and vein
C = Deep fibular nerve
D = Extensor digitorum longus
E = Fibularis tertius

POSTERIOR LOWER RIGHT LEG AND TENDONS AT MEDIAL ANKLE



Flexor digitorum longus crosses tibialis posterior in leg and flexor hallucis longus in foot

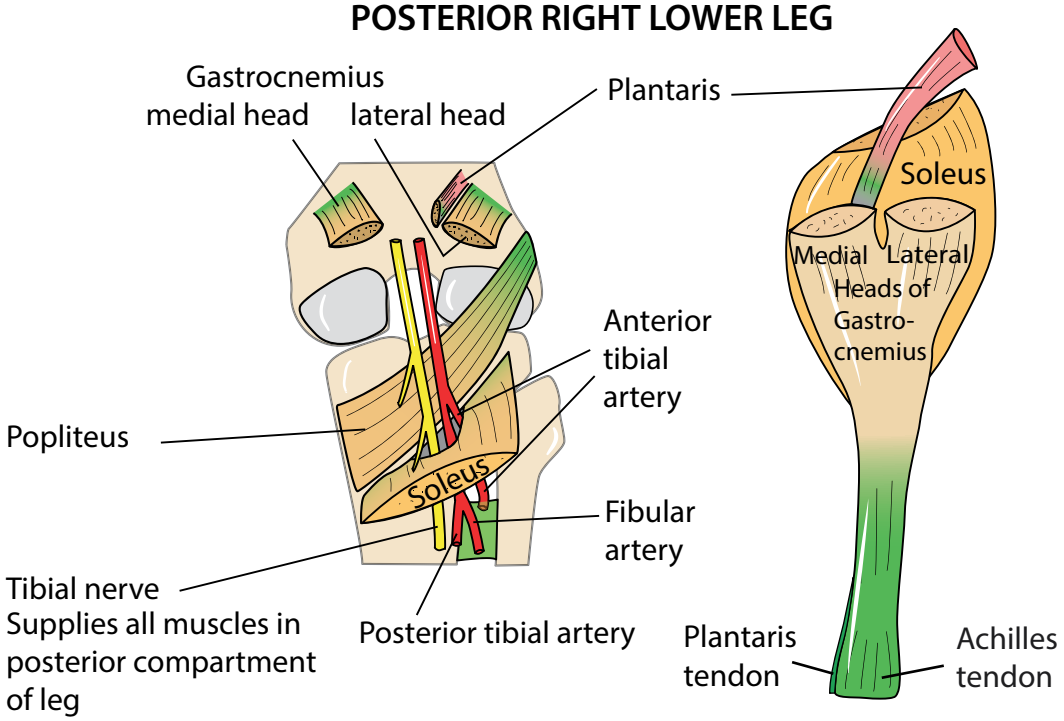


Tendons in foot

Order of structures behind medial malleolus (arrow): Tibialis posterior, flexor digitorum longus, posterior tibial vein and artery, tibial nerve, flexor hallucis longus

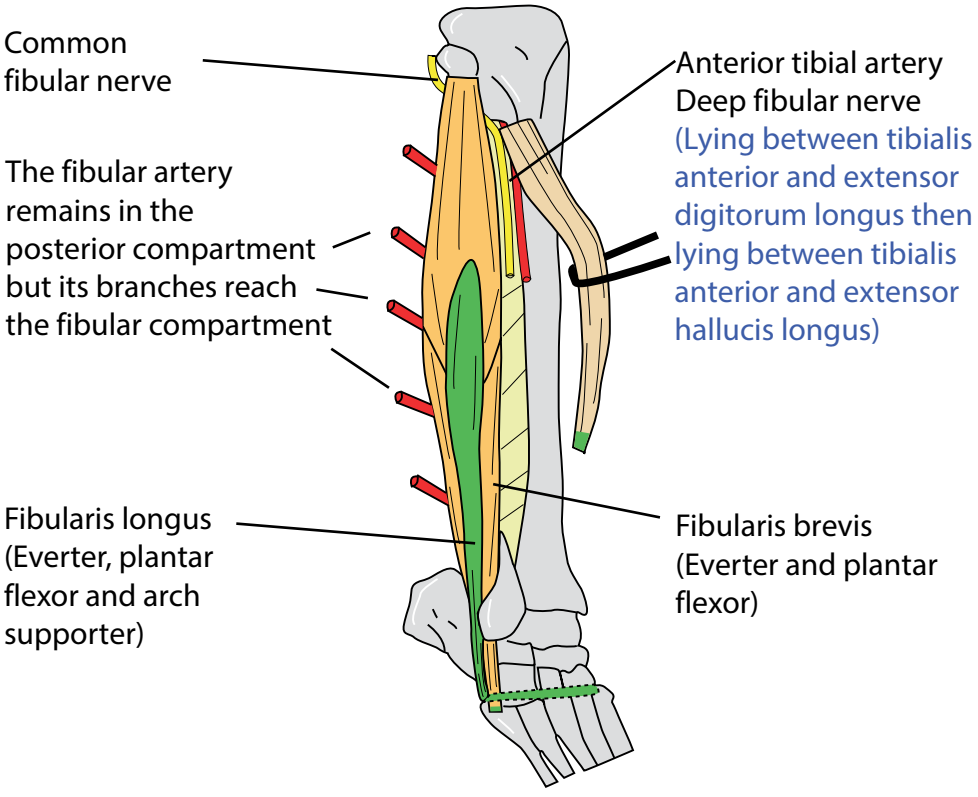
Mnemonic: Timothy Doth Vex All Nervous Housemaids OR: T

POSTERIOR RIGHT LOWER LEG



- Gastrocnemius crosses the knee and flexes it
- Soleus is the main venous muscle pump

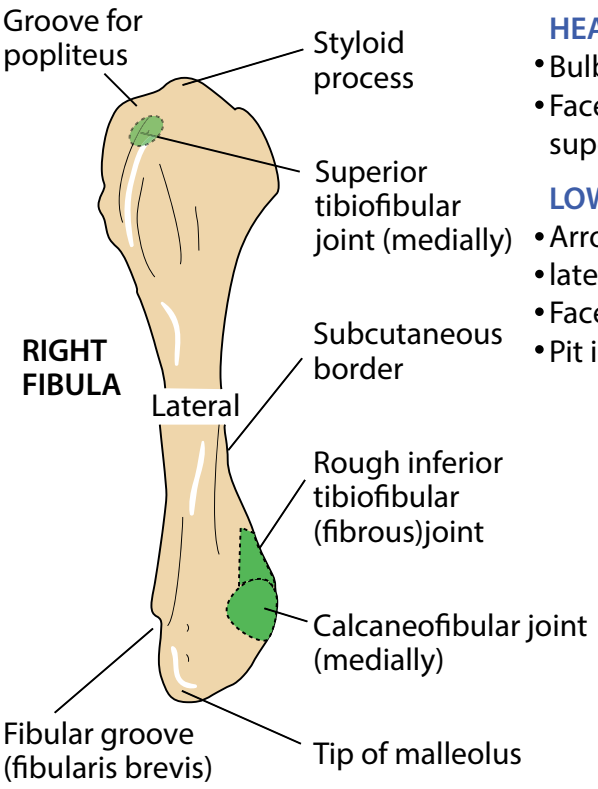
RIGHT LATERAL FIBULAR COMPARTMENT



POPLITEUS

Arises: Upper posterior surface of tibia
Inserts: Lateral epicondyle of femur
Nerve: Tibial
Tendon: passes laterally, initially within the capsule of the knee then medial to the lateral collateral ligament and may lightly attach to lateral meniscus

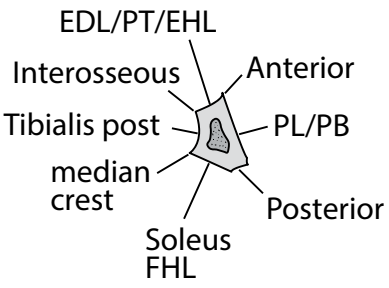
Action: Laterally rotates femur on tibia to unlock the knee. It may be able to pull the lateral meniscus out of the way during the initial flexion of the knee after locking

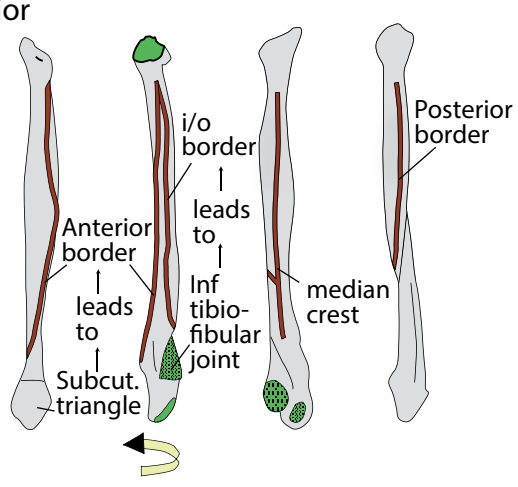


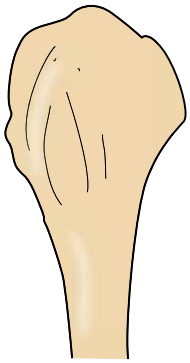
HEAD
- Bulbous
- Facet on superior surface

LOWER END
- Arrow shaped
- lateral malleolus
- Facet medial
- Pit is posterior

TIBIAL BORDERS



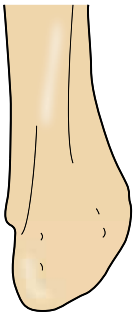




"SIDING" A FIBULA

HEAD

- Bulbous
- Facet on superior surface

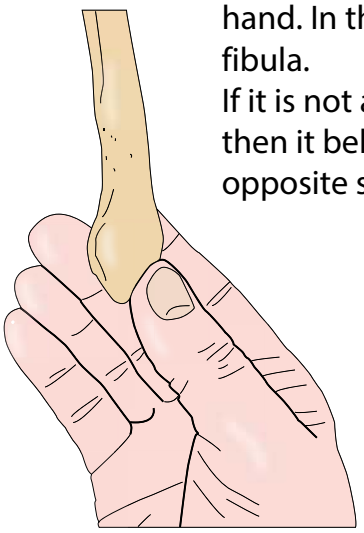


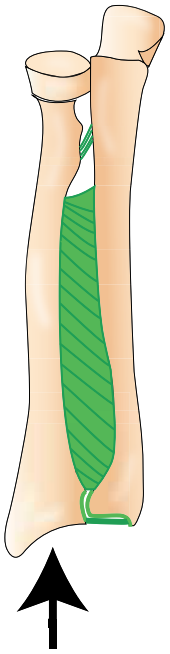
LOWER END

- Arrow shaped
- Lateral malleolus
- Facet medial
- Pit is posterior

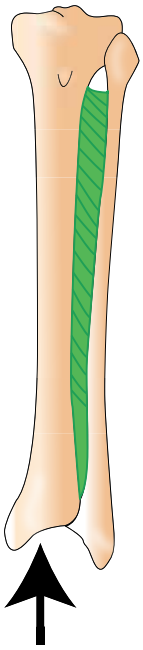
TO "SIDE" A FIBULA

Hold the lower end of the fibula with the pulp of your thumb sitting comfortably in the pit. If it fits easily then the fibula is the same side as your hand. In this case it is a right fibula.
If it is not a comfortable fit then it belongs to the opposite side.





Right radius and ulna



Left tibia and fibula

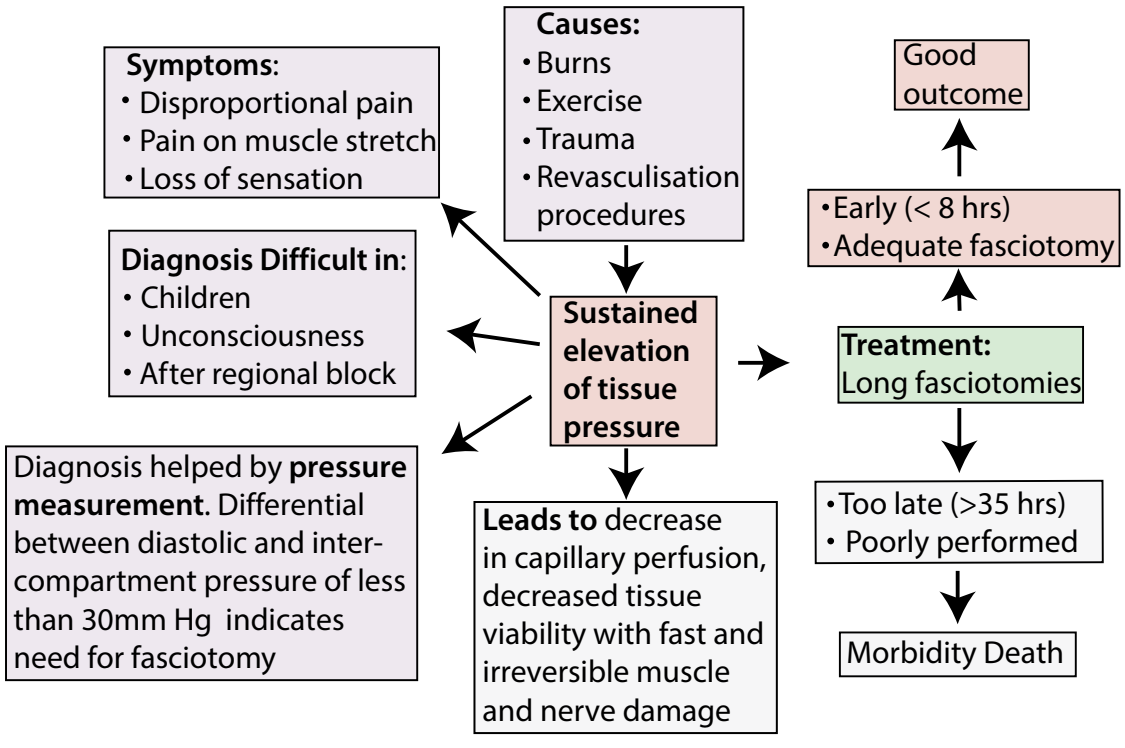
INTEROSSEOUS MEMBRANES

Forces from the hand and foot are transmitted respectively to the radius and tibia. In order to share the impact of the force the interosseous membranes have fibres arranged so that the ulna and the fibula can share the the strain easily and immediately

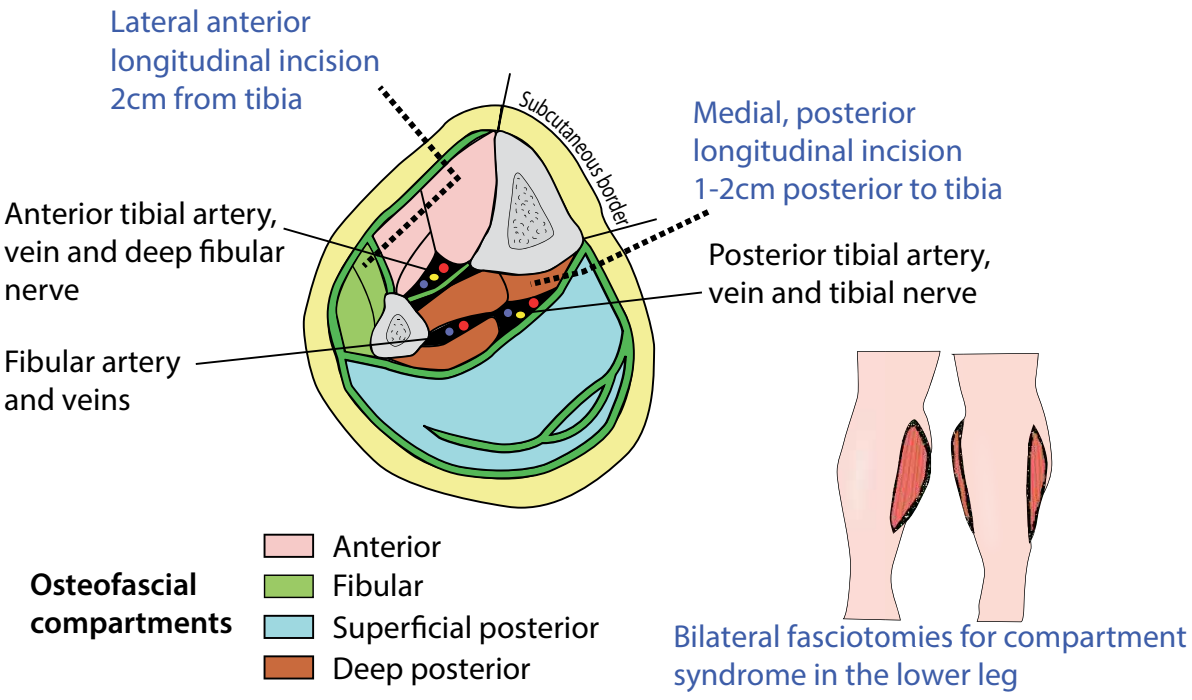
COMPARTMENT SYNDROMES OF LOWER LEG

SITE: Between tough deep fascia, intermuscular septa, bones and interosseous membrane
CAUSE: Trauma/infection leads to swelling, increased pressure, decreased perfusion, then ischaemia and tissue death
SYMPTOMS AND SIGNS: Pain, particularly on passive movement, decreased muscle and nerve function and loss of sensation. Pulse may be lost but often late in the course of events. A differential pressure between diastolic blood pressure and inter-compartmental pressure of 30mmHg or less is enough to cause damage and indicate the need for an operation
ANTERIOR: Pain, decreased dorsiflexion, extension of toes, loss of sensation in first dorsal skin cleft
LATERAL: Pain, decreased plantar flexion, inversion, loss of sensation of dorsal foot and toes
POSTERIOR: Divided by deep transverse intermuscular septum into superficial and deep syndromes. Superficial gives decreased plantar flexion and loss of sural nerve sensation. Deep gives decreased plantar and toe flexion, loss of tibial nerve sensation

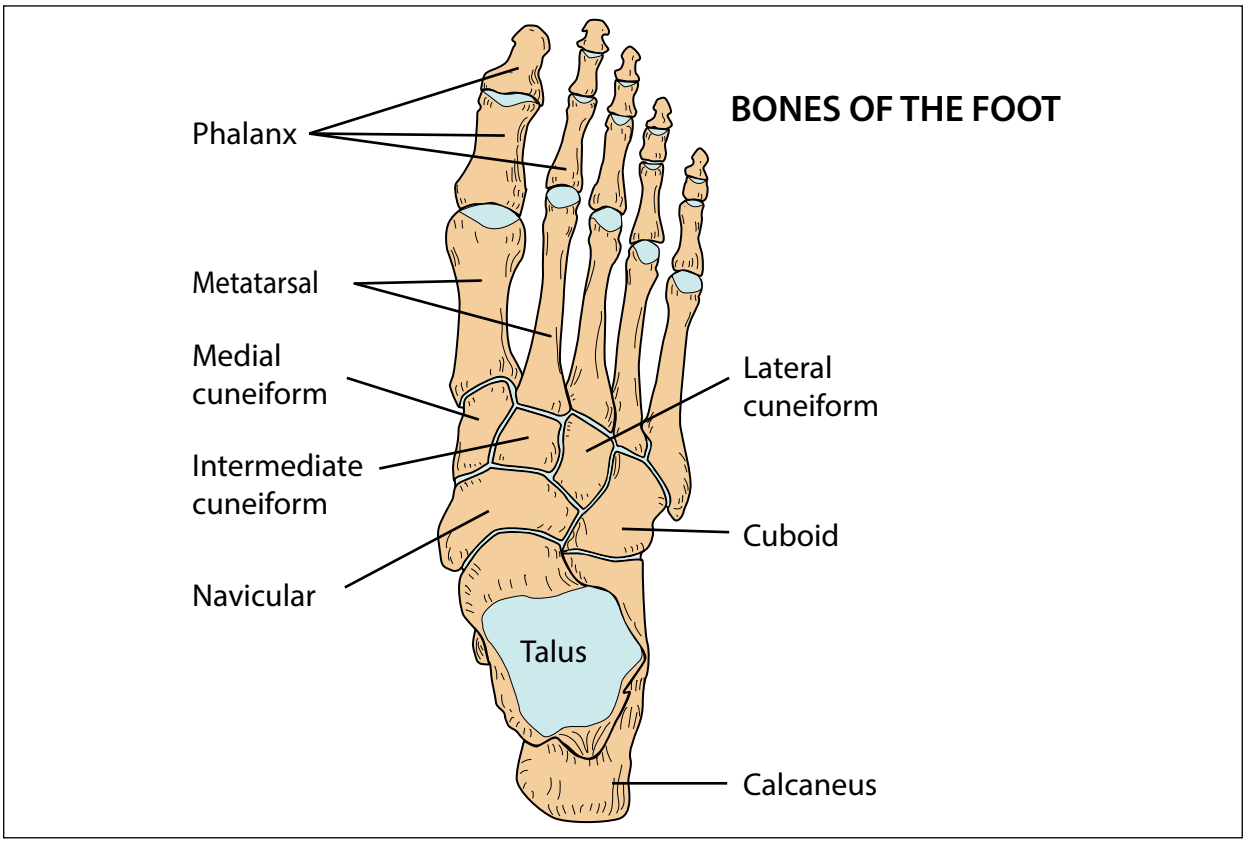
COMPARTMENT SYNDROMES

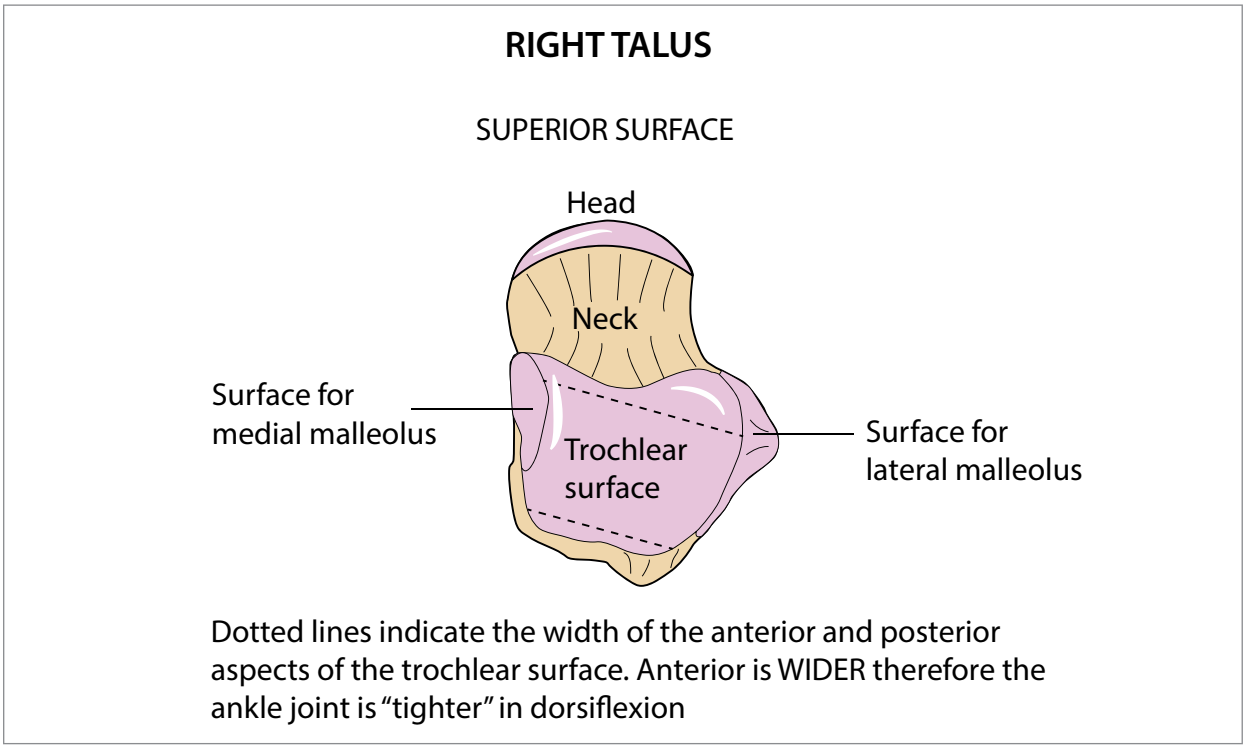


COMPARTMENT SYNDROMES AND FASCIOTOMIES



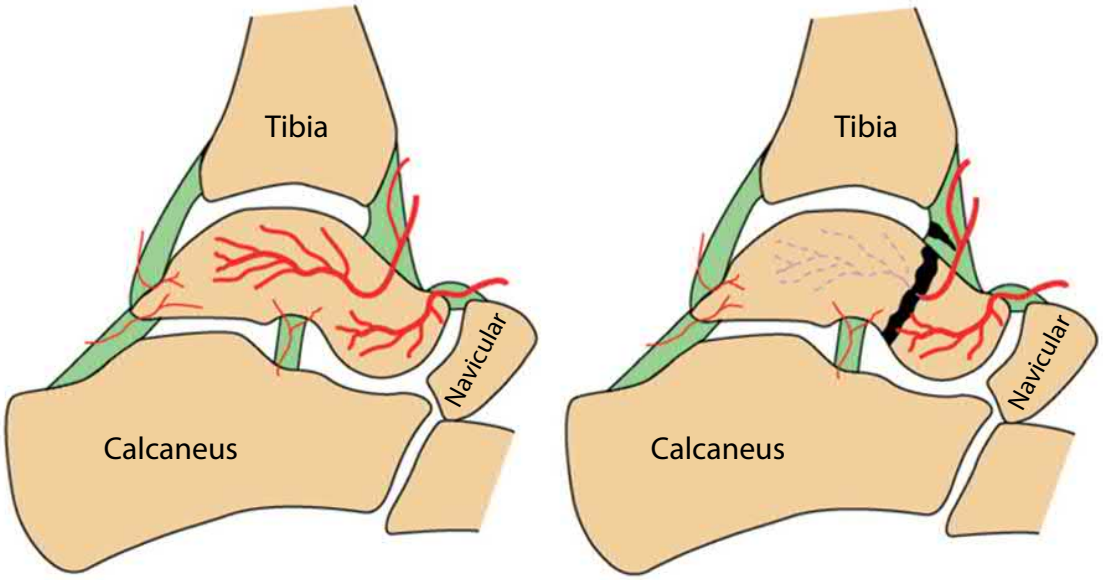
2.5 Ankle and Foot





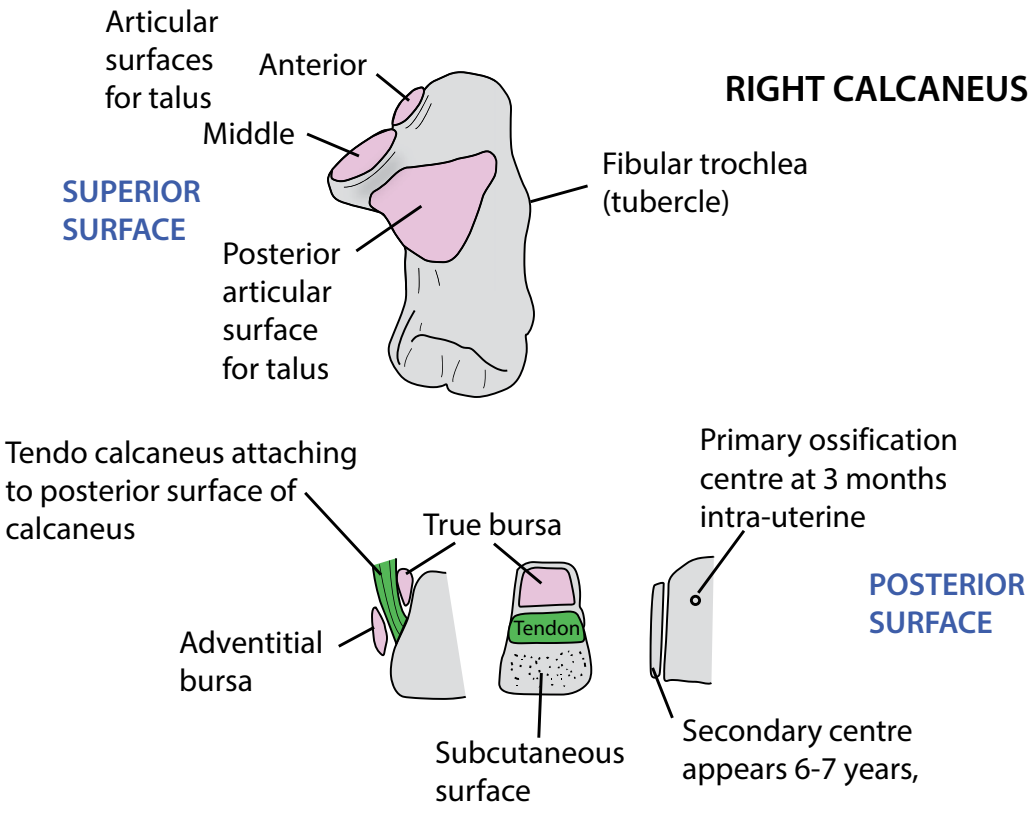
Dotted lines indicate the width of the anterior and posterior aspects of the trochlear surface. Anterior is WIDER therefore the ankle joint is "tighter" in dorsiflexion

FRACTURE OF NECK OF TALUS

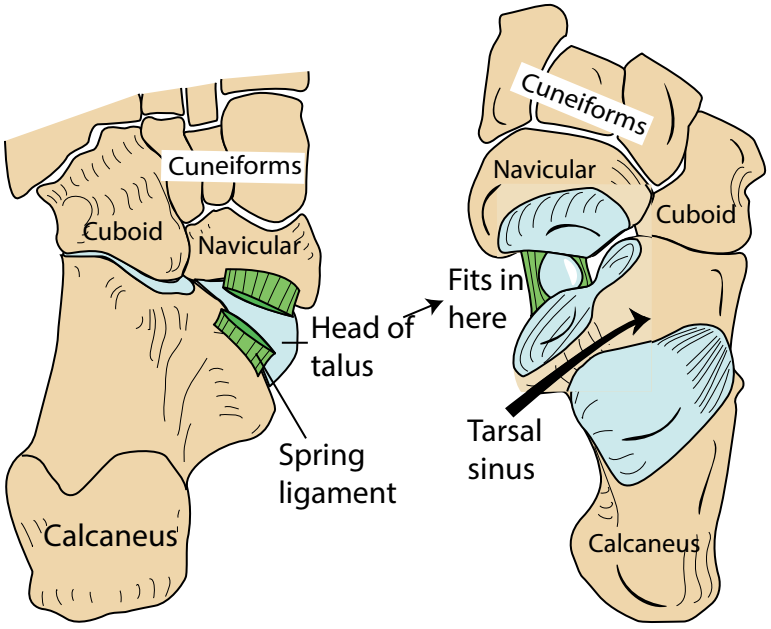


Similar to the scaphoid in the carpus, the talus has most of its blood supply entering distally. Thus a fracture of the neck often leads to avascular necrosis of its posterior part.

RIGHT CALCANEUS

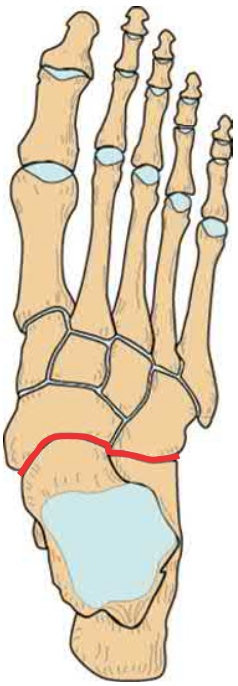


TALOCALCANEONAVICULAR JOINT



To show how the joint can be likened to a ball and socket with the head of the talus fitting into the combined facets on the navicular and calcaneus

MIDTARSAL JOINT



TALOCALCANEONAVICULAR

(effectively a ball and socket joint)

Made up of 2 parts

1

Between talus and calcaneus (2 joints)

Talocalcaneal (2 facets)

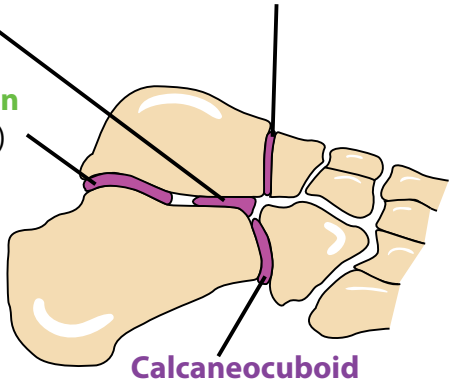
+

Talocalcanean joint (1 facet)

2

Between talus and navicular (Single joint)

Talonavicular



INVERSION AND EVERSION

SUBTALAR (3 facets)

Talocalcanean (posterior and separate, 1 facet)

+

Talocalcaneal part of talocalcaneonavicular (2 facets)

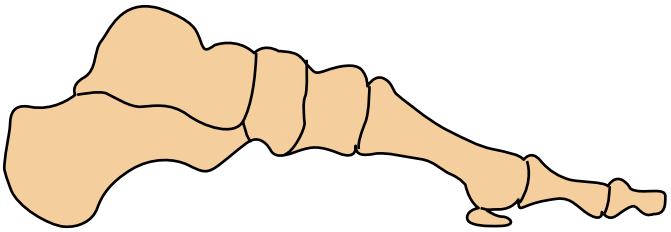
MIDTARSAL (2 facets)

Calcaneocuboid

+

Talonavicular part of the talocalcaneonavicular

ARCHES OF THE FOOT



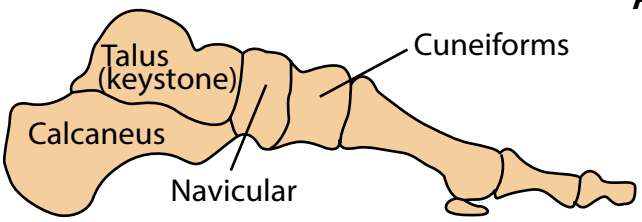
FOR:
Propulsion
Shock absorption
Resilience

FACTORS:
Shape of bones
Ligaments (+ plantar fascia)
Tendons
Tone of small muscles

There is varying dominance of each of these factors in the medial, lateral and transverse arches

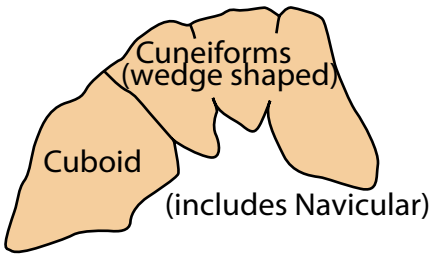
ARCHES OF THE FOOT

Medial longitudinal arch

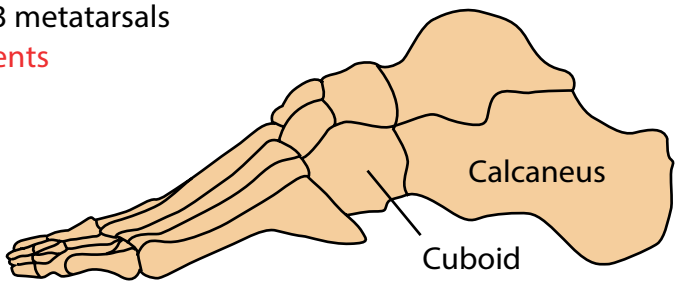


+ Spring ligament
+ Short and long plantar ligaments
+ Plantar fascia
+ Tibialis anterior and posterior
+ Flexor hallucis longus
+ Fibularis longus

Transverse arch



Lateral longitudinal arch

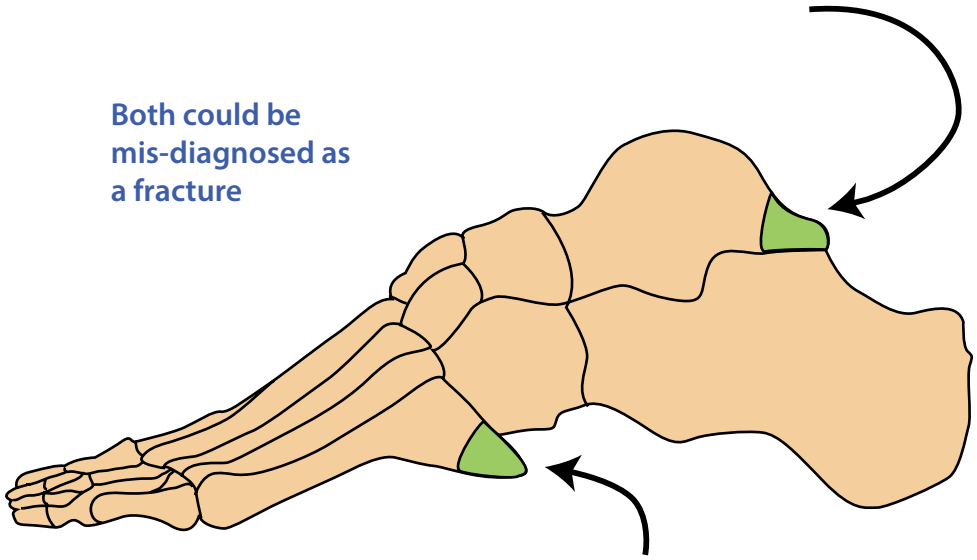


+ Short/long plantar ligaments
+ Fibularis longus and brevis
+ Plantar fascia

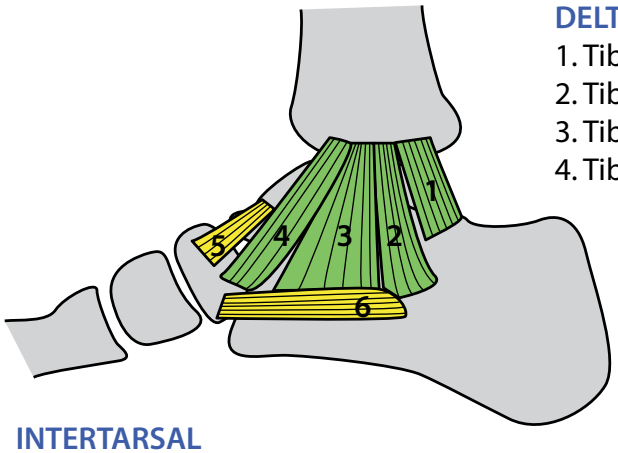
ACCESSORY OSSIFICATION OF FOOT BONES

Posterior process of talus may have its own ossification centre that fails to fuse = **OS TRIGONUM**

Both could be mis-diagnosed as a fracture



Similarly with the base of the 5th metatarsal = **OS VESALIANUM**



DELTOID/MEDIAL COLLATERAL

1. Tibiotalar (posterior)
2. Tibiosustenacular
3. Tibio-spring ligament
4. Tibionavicular

LIGAMENTS OF MEDIAL SIDE OF RIGHT ANKLE

INTERTARSAL

5. Talonavicular
6. Spring (plantar calcaneo-navicular)
   Thick, strong, non-elastic, from sustenaculum tali to navicular. Upper surface articulates with head of talus.

Joints

Intertarsal

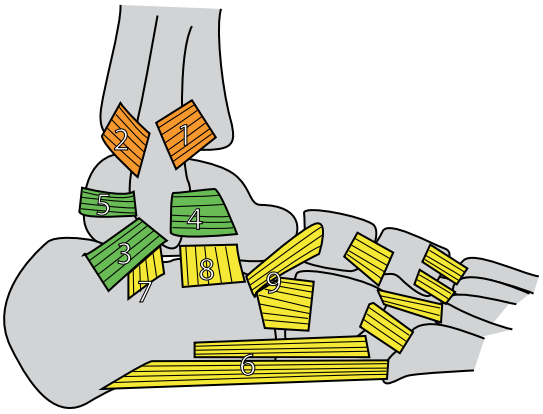
Ankle

LIGAMENTS ON LATERAL SIDE OF RIGHT ANKLE

INFERIOR TIBIOFIBULAR LIGAMENT
1. Anterior tibiofibular
2. Posterior tibiofibular

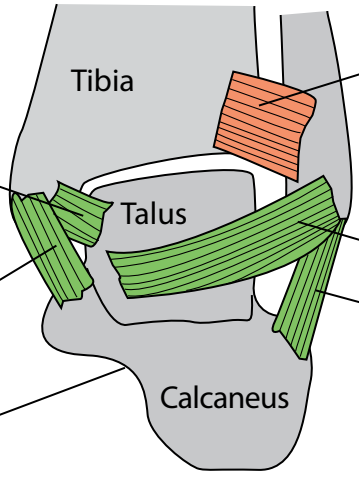
LATERAL COLLATERAL LIGAMENT
3. Calcaneofibular
4. Anterior talofibular
5. Posterior talofibular

TARSAL/METATARSAL LIGAMENTS
6. Short/long plantar
7. Lateral talocalcaneal
8. Cervical
9. Bifurcate



Joints
- Inferior tibiofibular
- Ankle
- Intertarsal

POSTERIOR VIEW OF RIGHT ANKLE



Posterior tibiofibular

Tibiotalar (part of deltoid)

Tibiosustentacular (part of deltoid)

Groove for flexor hallucis longus

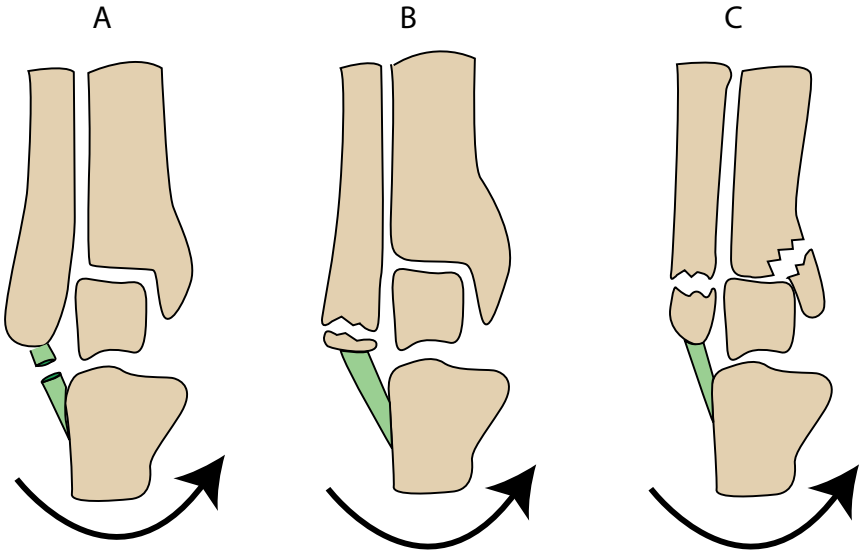
Posterior talofibular

Calcaneofibular

Because the fibula sticks out more laterally from the ankle joint than the tibia, the 3 parts of the lateral ligament are less strong and are easily torn in an inversion injury

Joints
- Tibiofibular
- Ankle

INVERSION INJURIES OF ANKLE

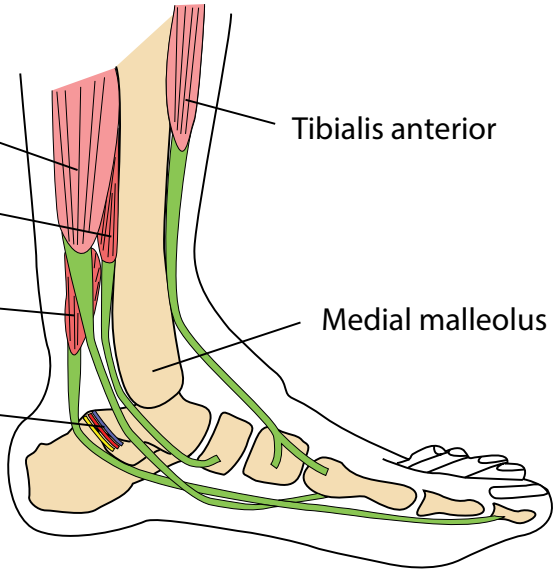


A: Sprain or tear of calcaneofibular ligament

B: Avulsion of lateral malleolus

C: Avulsion of lateral malleolus and "push" fracture of medial malleolus

TENDON AND NEUROVASCULAR RELATIONSHIPS ON MEDIAL ASPECTS OF ANKLE

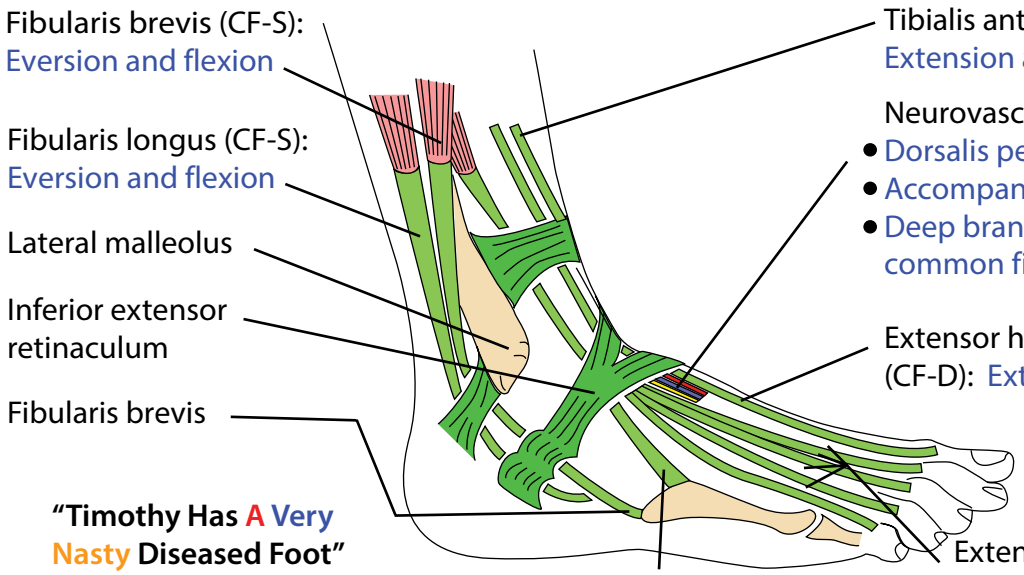


(T) = Tibial Nerve

"Timothy Doth Vex All Nervous Housemaids"
or **"Tom, Dick And A Very Nervous Harry"**

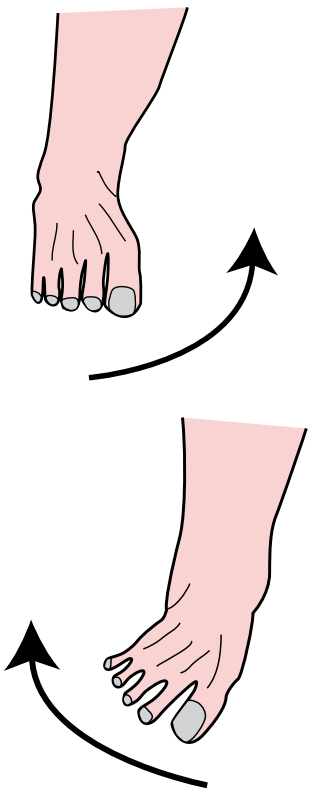
Order of structures behind medial malleolus from anterior to posterior: Tibialis posterior, flexor digitorum longus, posterior tibial vein and artery, tibial nerve, flexor hallucis longus

TENDON AND NEUROVASCULAR RELATIONSHIPS ON LATERAL ASPECTS OF RIGHT ANKLE



(CF-S) = Superficial br of common fibular nerve. (CF-D) = Deep br of common fibular nerve

INVERSION AND EVERSION

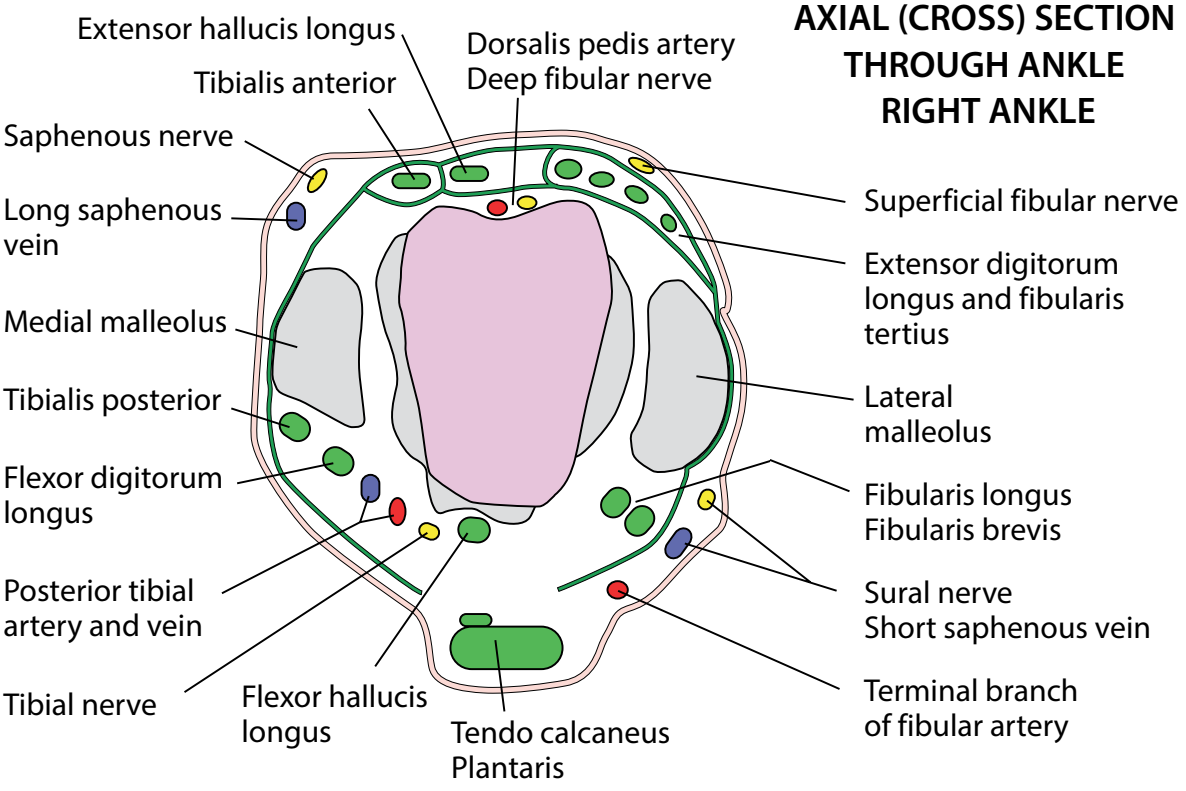


INVERSION
Always with some adduction of toes.
Muscles: Tibialis anterior/posterior (+/– extensor hallucis longus and flexor digitorum longus).

EVERSION
Always with some abduction of toes.
Muscles: Fibularis longus/brevis; fibularis tertius and extensor digitorum longus when foot is extended.

NOTE: As all these tendons insert distal to the midtarsal joint; this joint moves first and a little. But soon reaches its maximum and the torque is then transmitted to the subtalar joint which gives most of each movement.

AXIAL (CROSS) SECTION THROUGH ANKLE RIGHT ANKLE

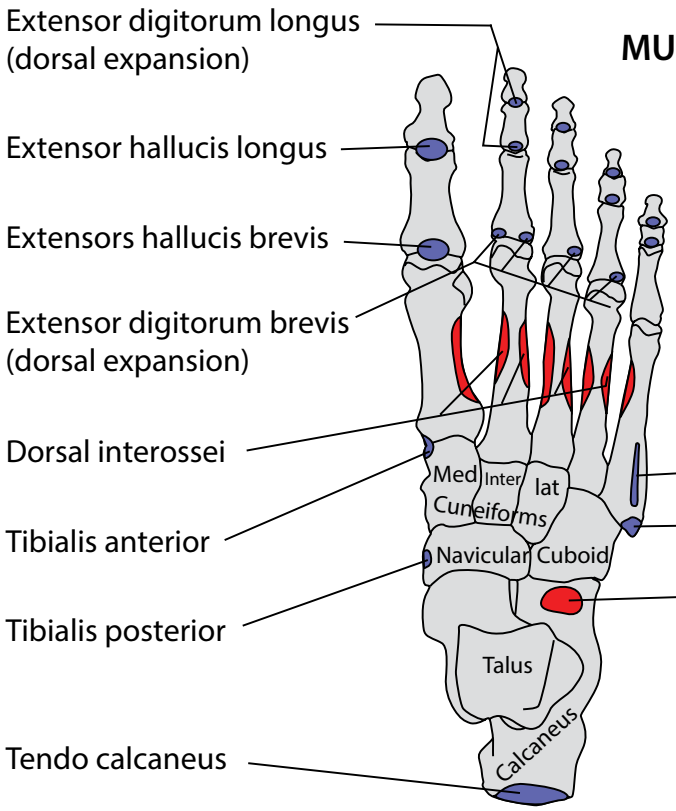


COMPARISON OF MUSCLES/TENDONS AND THEIR NERVE SUPPLY IN HAND AND FOOT

HAND MUSCLES (palmar)	NERVE IN HAND	FOOT MUSCLES (plantar)	NERVE IN FOOT
Interossei(ref to middle finger)	Ulnar	Interossei (ref to 2nd toe)	Lateral plantar
Lumbricals 1 and 2	Median	Lumbricals 1	Medial plantar
Lumbricals 3, 4	Ulnar	Lumbricals 2, 3, 4	Lateral plantar
Thenar (abductor pollicis brevis, flexor pollicis brevis, opponens pollicis	Median	To hallux (abductor hallucis flexor hallucis brevis)	Medial plantar
Adductor pollicis	Ulnar	Adductor hallucis	Lateral plantar
Hypothenar (abductor digiti minimi, flexor digiti minimi brevis, opponens digiti minimi)	Ulnar	To 5th toe (abductor digiti minimi, flexor digiti minimi brevis)	Lateral plantar
Flexor digitorum superficialis	Median	Flexor digitorum brevis	Medial plantar

Note: There is no equivalent in the upper limb of **quadratus plantae** (flexor accessorius) which is supplied by the lateral plantar nerve. Easy to remember as this muscle arises on the lateral side of the foot.

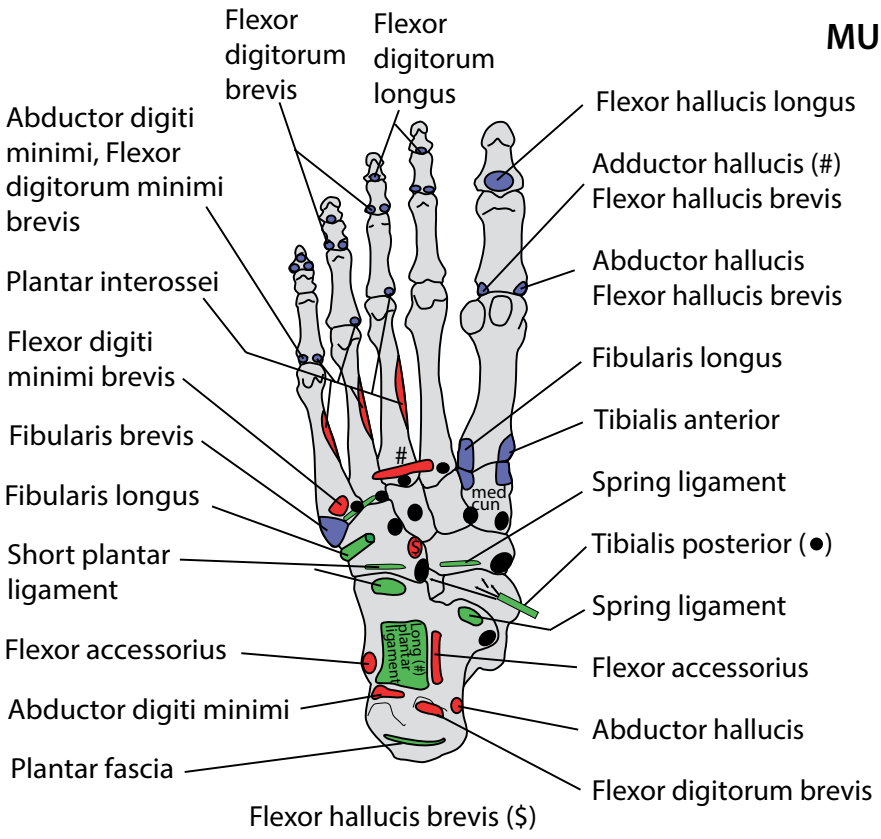
This table clearly shows that the lateral plantar nerve is the equivalent to the ulnar nerve and the medial plantar is equivalent to the median nerve.



MUSCLE ATTACHMENTS TO RIGHT FOOT

DORSUM

RED - Origins
Blue - insertions

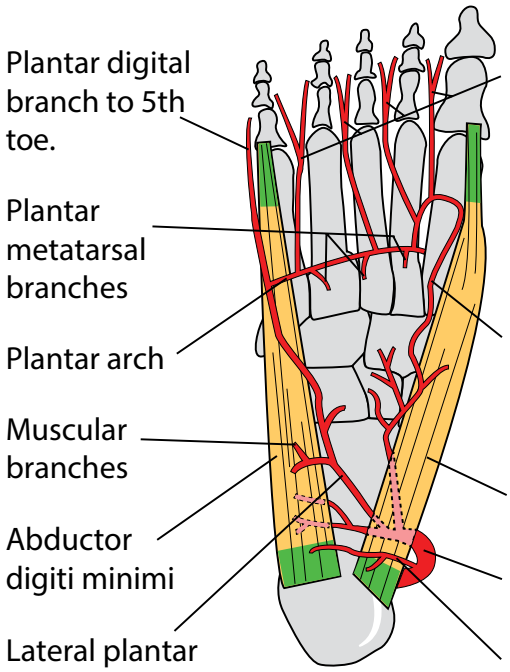


MUSCLE ATTACHMENTS TO RIGHT FOOT

PLANTAR

Tarsal sinus
Between talocalcaneonavicular and talocalcanean joints. Contains ligaments between bones. Closed off by cervical ligament, extensor digitorum brevis, extensor retinaculum.
Talus: No muscles attached, almost entirely intra-articular, neck blood supplies body (avascular necrosis with fracture likely)

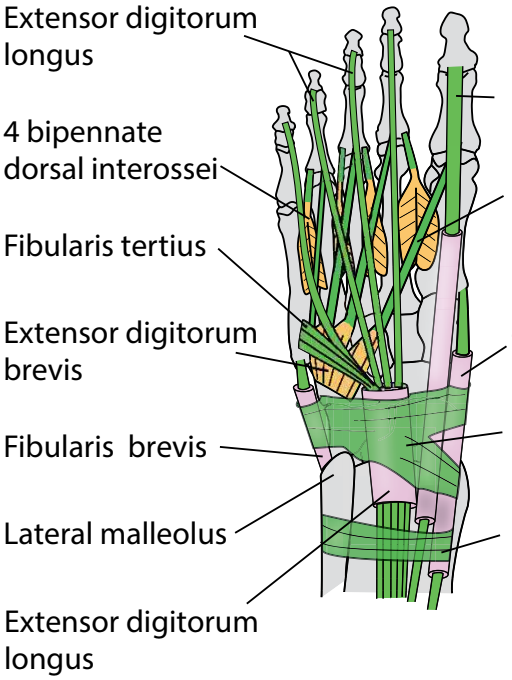
ARTERIES IN SOLE OF RIGHT FOOT



THE NEUROVASCULAR PLANE
Lies between 1st and 2nd layers. Has arteries lying marginal and nerves central

PLANTAR ARCH (lateral plantar artery)
Anastomotic vessels from this arch pass:
1. Between the 1st and 2nd metatarsals to dorsalis pedis artery
2. Between 2/3, 3/4, 4/5 metatarsals to dorsal metatarsal arteries

DORSUM OF LEFT FOOT



Extensor digitorum brevis

Arises: Superior/anterior calcaneus.

Inserts: 4 tendons. Proximal phalanx big toe (could be called extensor hallucis brevis) and into long extensor tendons to 2,3,4.

Acts: Extends toes 1-4 when foot is fully dorsiflexed.

Nerve: Deep fibular (L5,S1).

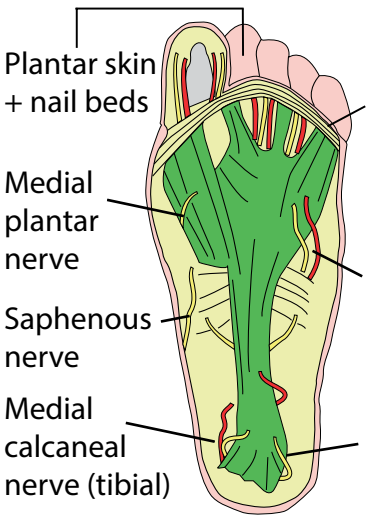
Note: This muscle breaks the rule in that, as a short "digitorum" muscle, it does not supply the 5th digit (cf. Flexor digitorum superficialis in hand)

LAYERS OF THE SOLE OF FOOT

PLANTAR APONEUROSIS

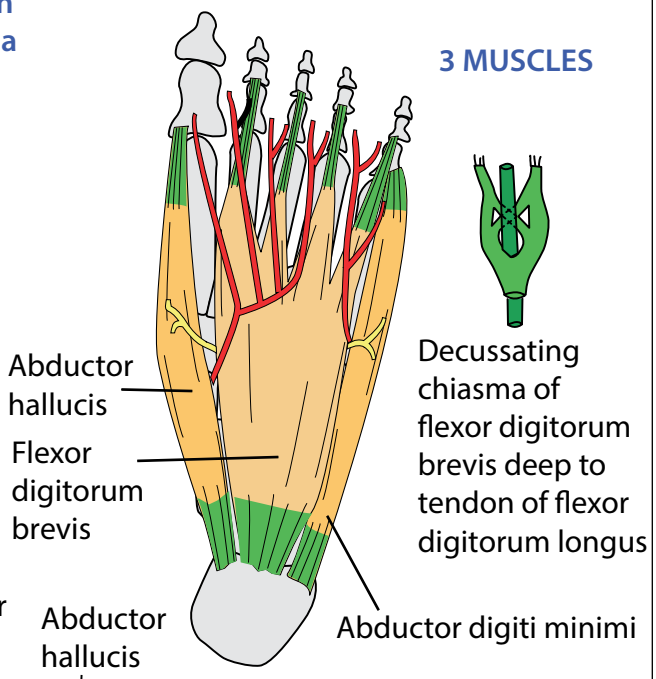
LAYER 1	3 MUSCLES (ABH, ABDM, FDB)
	NEUROVASCULAR PLANE
LAYER 2	2 MUSCLES (LUMBRICALS, ACCESSORIUS) 2 TENDONS (FHL, FDL)
LAYER 3	3 MUSCLES (ADH, FHB, FDMB) 2 LIGAMENTS (SPRING, LONG PLANTAR)
LAYER 4	1 MUSCLE (INTEROSSEI) 1 LIGAMENT (SHORT PLANTAR) 3 TENDONS (FL, TP, TA)

PLANTAR APONEUROSIS



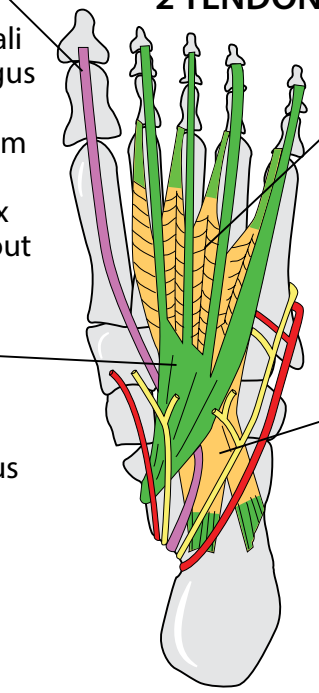
Origin: Posterior calcaneal tuberosity
Insertion: 5 slips into toe pads/skin, edges of fibrous flexor sheaths, superficial transverse metatarsal ligaments

FIRST LAYER OF SOLE OF FOOT



SECOND LAYER OF SOLE OF LEFT FOOT

2 MUSCLES
2 TENDONS



Tendon of flexor hallucis longus

- Grooves sustentaculum tali
- Crossed by flexor dig longus
- Gives slips to medial 2 tendons of flexor digitorum longus
- Into base of distal phalanx
- Synovial sheath throughout (opened distally here)

Tendon of flexor digitorum longus

- Crosses superficial to flexor hallucis longus
- Receives flexor accessorius
- Gives off lumbricals
- Receives 2 slips from flexor hallucis longus to 2 medial tendons
- To base of distal phalanges via fibrous flexor sheaths

Lumbricals

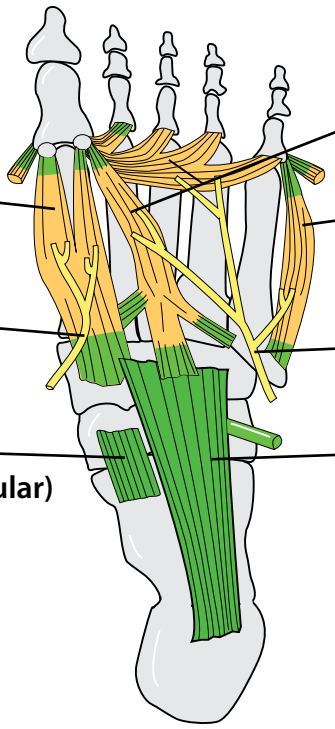
- Lateral 3 are bipennate and are between tendons of flexor digitorum longus (lateral plantar nerve).
- Medial one from medial side of 1st tendon and is unipennate (medial plantar nerve)

Flexor accessorius

- 2 heads.
- Pulls flexor digitorum longus tendons so that they pull straight.
- Assists the long tendons with flexion of lateral 4 toes when ankle is flexed (lateral plantar nerve)

THIRD LAYER OF SOLE OF LEFT FOOT

3 MUSCLES
2 LIGAMENTS



Adductor hallucis

Flexor hallucis brevis

Flexor digiti minimi brevis

Medial plantar nerve

Lateral plantar nerve

Spring ligament (plantar calcaneonavicular)

From sustentaculum tali to navicular.
Tibialis posterior runs superficial to it

Long plantar ligament

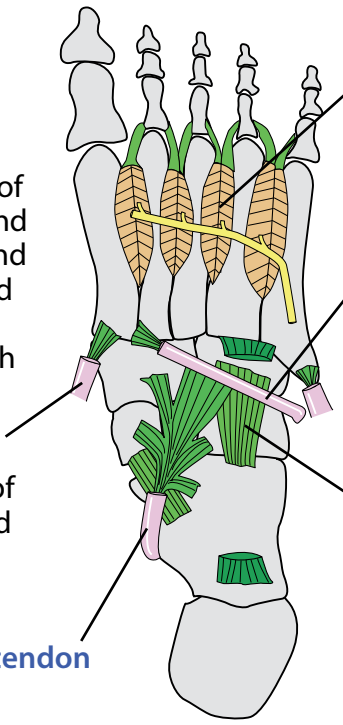
Under surface of calcaneus between posterior tuberosity and anterior tubercle to ridge and tuberosity of cuboid and bases of 2nd, 3rd and 4th metatarsals. Fibularis longus runs deep to it

FOURTH LAYER OF SOLE OF LEFT FOOT

1 MUSCLE
1 LIGAMENT
3 TENDONS

Unipennate plantar interossei arise medial sides of 3,4,5 metatarsals, insert medial bases of proximal phalanges with slips to dorsal expansion of 3,4,5. Adduct 3,4,5 toes and assists lumbricals to extend interphalangeal joints and flex metatarsophalangeal joints. **Nerve:** deep branch of lateral plantar nerve.

Tibialis anterior tendon
(Inserts into medial side of base of 1st metatarsal and medial cuneiform)



Tibialis posterior tendon

Dorsal and plantar interossei

Fibularis longus tendon
(In synovial sheath between long and short plantar ligaments. Across cuboid and cuneiforms into lateral base of 1st metatarsal and medial cuneiform)

Short plantar ligament
(plantar calcaneocuboid)
(Anterior calcaneal tubercle to cuboid)

SECTION 3

Thorax

3.1 Surface Anatomy and Breast, *148*
3.2 Mediastinum, Thoracic Inlet, Diaphragm and Lymphatics, *159*
3.3 Heart and Pericardium, *166*
3.4 Trachea, Lungs and Oesophagus, *187*
3.5 Vessels and Nerves, *200*
3.6 Cross Sections, *207*

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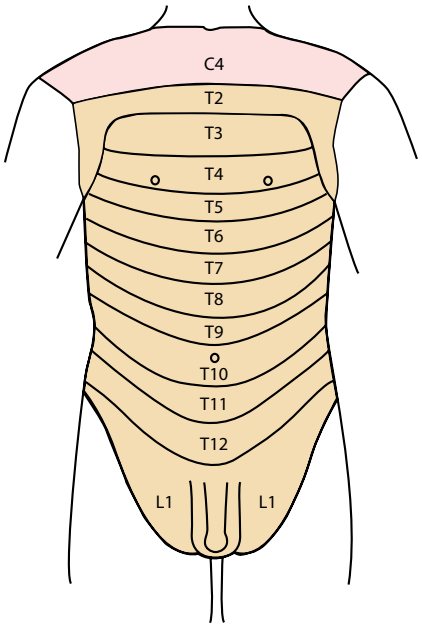
3.1 Surface Anatomy and Breast

Dermatomes

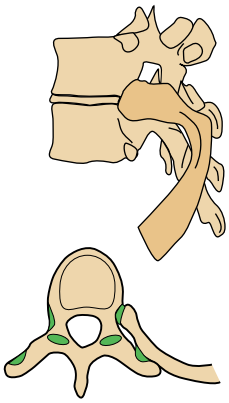


Nipples in T4 dermatome
Umbilicus in T10 dermatome

VERTEBRAL LEVELS IN THORAX

T2/3 **Suprasternal notch**
T3 Spine of T3; posterior end of oblique fissure of lung
T3-4 Manubrium; vertebral bodies of T3 and T4
T3/4 Top of aortic arch
T4/5 **Manubriosternal junction** (Angle of Louis): under surface of arch of aorta; bifurcation of pulmonary artery; bifurcation of trachea; left recurrent laryngeal nerve; ligamentum arteriosum; rib 2 anteriorly
T5 Thoracic duct crosses midline
T8 **Caval opening in diaphragm:** IVC with right phrenic nerve; left phrenic pierces muscle of diaphragm; hemi-azygos veins cross to right to join azygos vein
T10 **Oesophageal opening in diaphragm:** oesophagus; branches of left gastric vessels; vagus nerves
T12 **Aortic opening in diaphragm:** aorta; azygos and hemi-azygos veins; thoracic duct; origin of coeliac axis

RIB ARTICULATIONS WITH VERTEBRAE



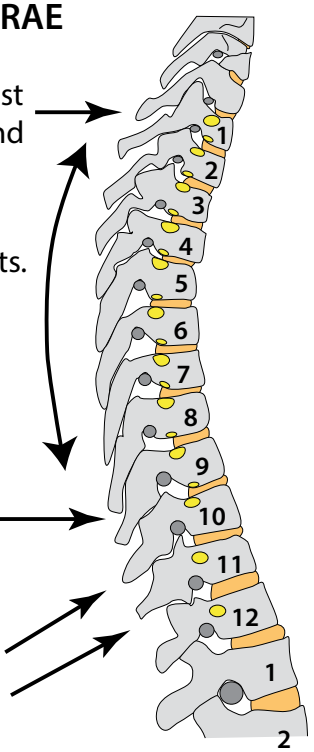
Each ribs articulates with its own transverse process by a synovial joint except ribs 11 and 12 which do so with a fibrous joint

T1 has whole facet for 1st rib and hemifacet for 2nd rib

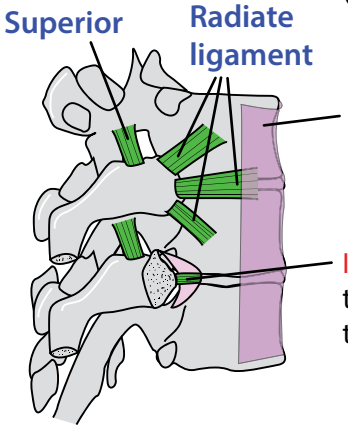
T2 - T9 have 2 hemifacets. The upper one for its own rib and the lower one for the rib below

T10 has one half facet only for its own rib

T11 and T12 have whole facets for their own ribs



COSTOTRANSVERSE LIGAMENTS

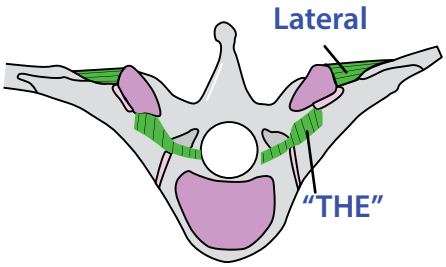


Other ligaments include:

Anterior longitudinal ligament
Runs along anterior bodies and attaches firmly to vertebral body and disc

Intra-articular ligament: From transverse crest of head of rib to intervertebral disc

Radiate ligament (3 parts)
To body above (upper); to own body (lower); hypochordal bow (middle) which lies deep to anterior longitudinal ligament and blends with intervertebral disc and fibres from other side



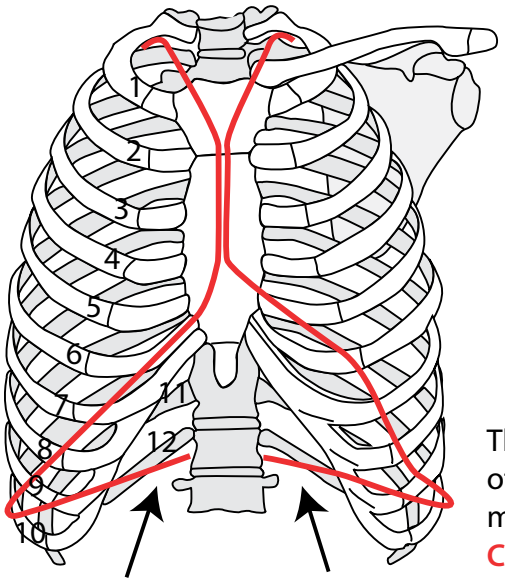
The costotransverse ligament connects rib to transverse process. It has 3 parts (confusing terminology):

"THE" costotransverse ligament
Fills gap between rib and its own transverse process

LATERAL costotransverse ligament
Lies posteriorly and extends from transverse process to its own rib, just beyond the tubercle

SUPERIOR costotransverse ligament
A 2 layered ligament with fibres at right angles to each other (corresponding and continuous with the intercostal muscles). Passes from upper border of neck of rib to transverse process of vertebra above

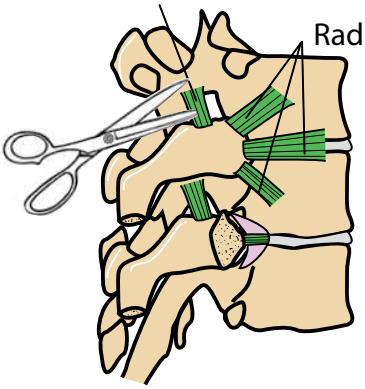
SUPRA-11TH OR SUPRA-12TH INCISION



PLEURA POSTERIORLY EXTENDS JUST BELOW 12TH RIB

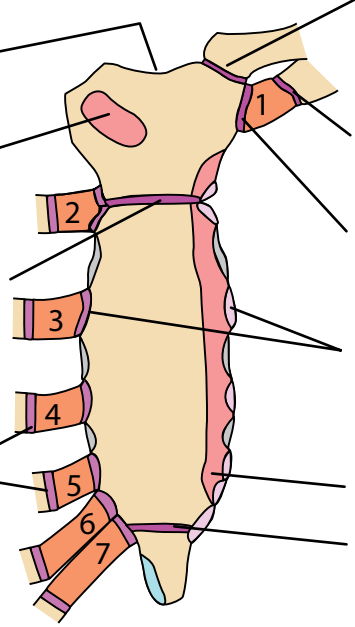
Superior costotransverse ligament

Radiate ligament



The periosteum of the rib is incised and lifted off the superior aspect. The rib must be mobilised by cutting the SUPERIOR COSTOTRANSVERSE LIGAMENT by running a pair of scissors along its superior surface. **Also the last few slips of the diaphragm must be cut to free it and avoid tearing the attached pleura.**

STERNUM AND RELATED JOINTS



Suprasternal (jugular) notch. T2/3

Sternocleidomastoid

Manubriosternal junction (angle of Louis), **secondary cartilaginous** (usually does not fuse)

Costochondral joints (all **primary cartilaginous**)

Sternoclavicular joint **(atypical synovial)**. Many features of a ball and socket joint but is not classified as such

1st costchondral **(primary cartilaginous)**

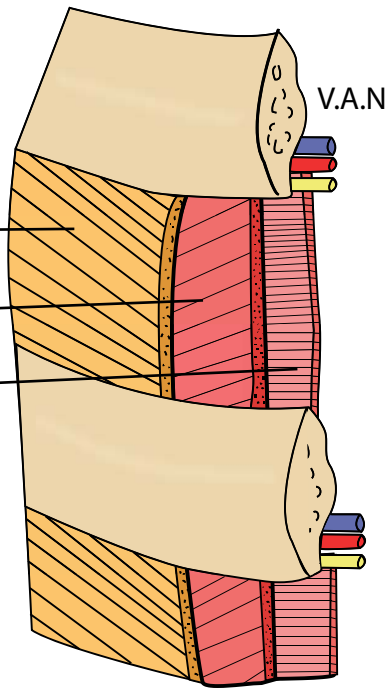
1st sternochondral **(primary cartilaginous)**

3-7 sternochondral (**atypical synovial**, single cavity)

Pectoralis major

Xiphisternal **(secondary cartilaginous)** (Usually fuses by 40yr)

CHEST WALL



External intercostal muscle

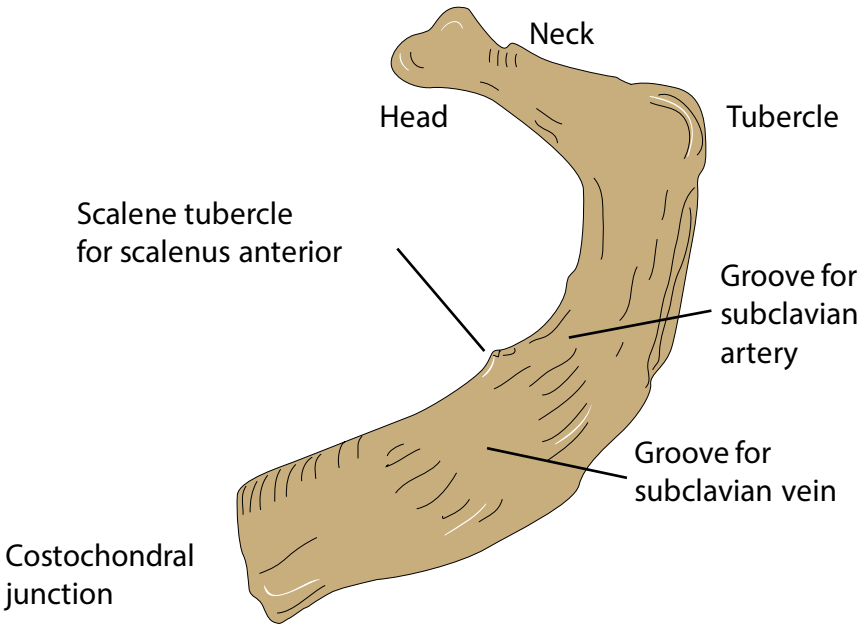
Internal intercostal muscle

Innermost intercostal muscle

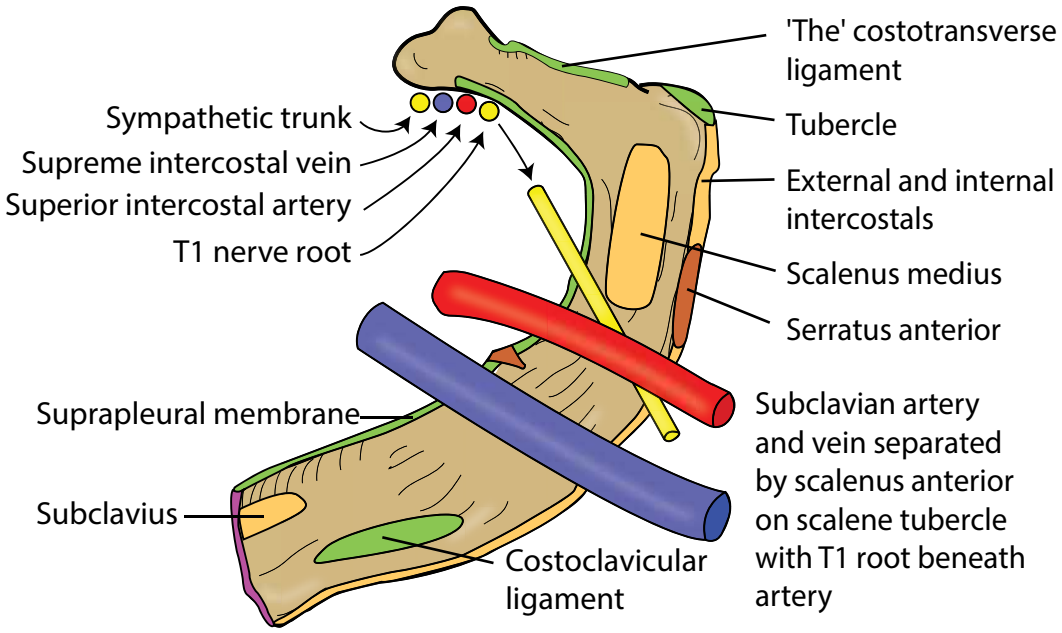
Deep to the inferior margin of each rib from superiorly to inferiorly:

V.A.N. = **V**ein, **A**rtery, **N**erve

LEFT FIRST RIB

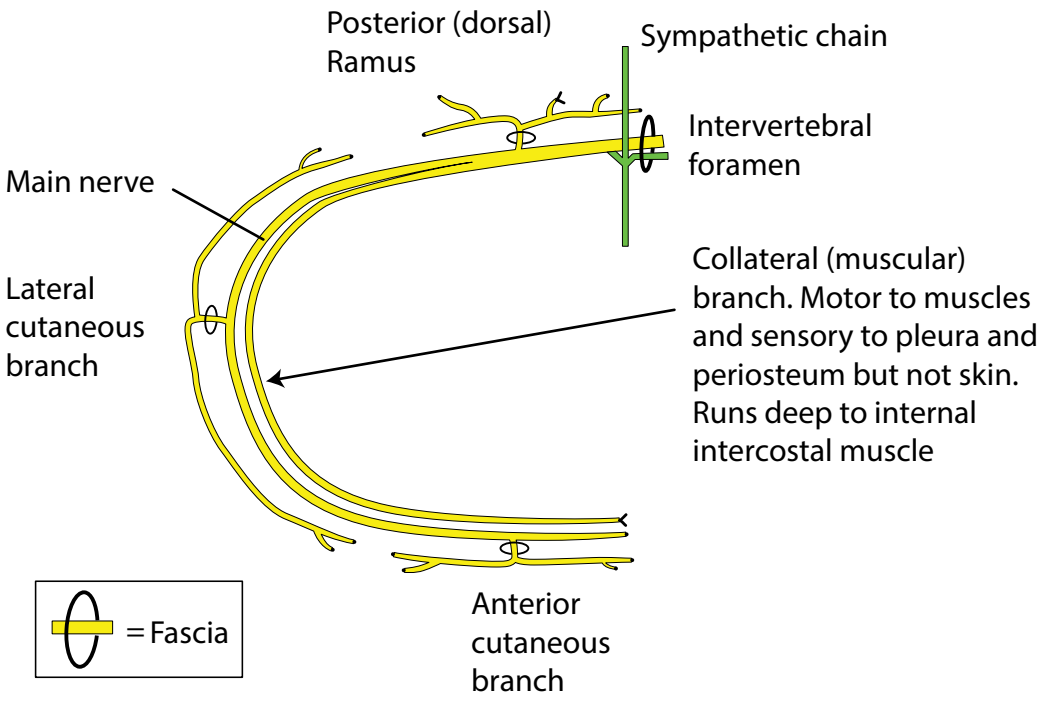


RELATIONS AND ATTACHMENTS OF LEFT FIRST RIB

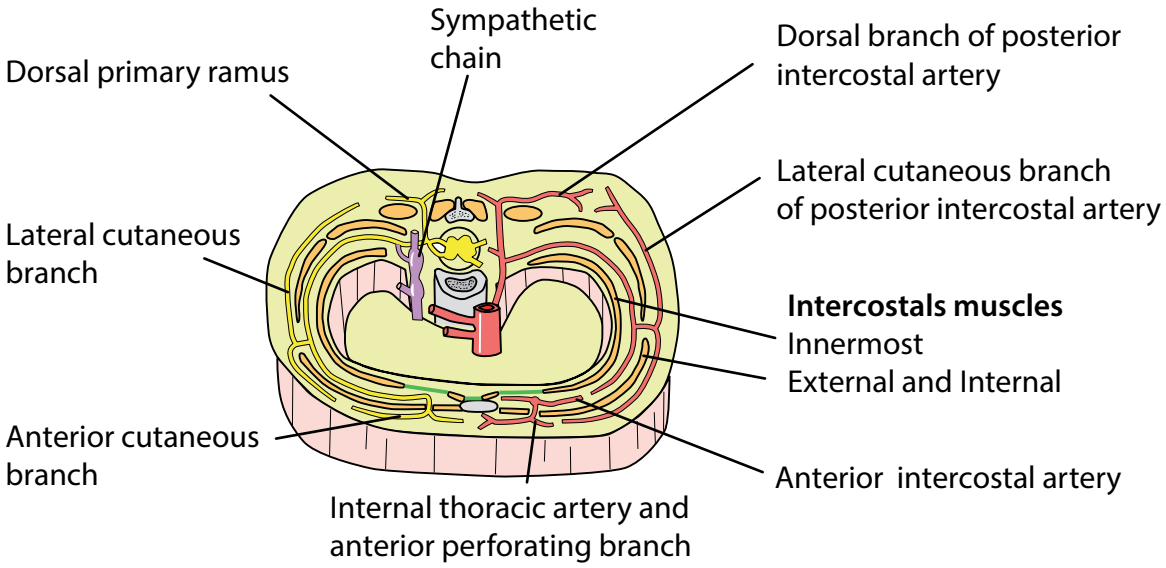


The under surface of the 1st rib is smoother. When the rib is laid on a flat surface, the head touches the flat surface when the rib is the correct way up

TYPICAL INTERCOSTAL NERVE



INTERCOSTAL NERVES AND ARTERIES



Note:

- Nerve is always external to the artery
- 1st thoracic nerve has no lateral cutaneous branch
- Nerves T7 - T11 also supply the abdominal wall

THORAX - SURFACE MARKINGS - CLINICAL IMPLICATIONS

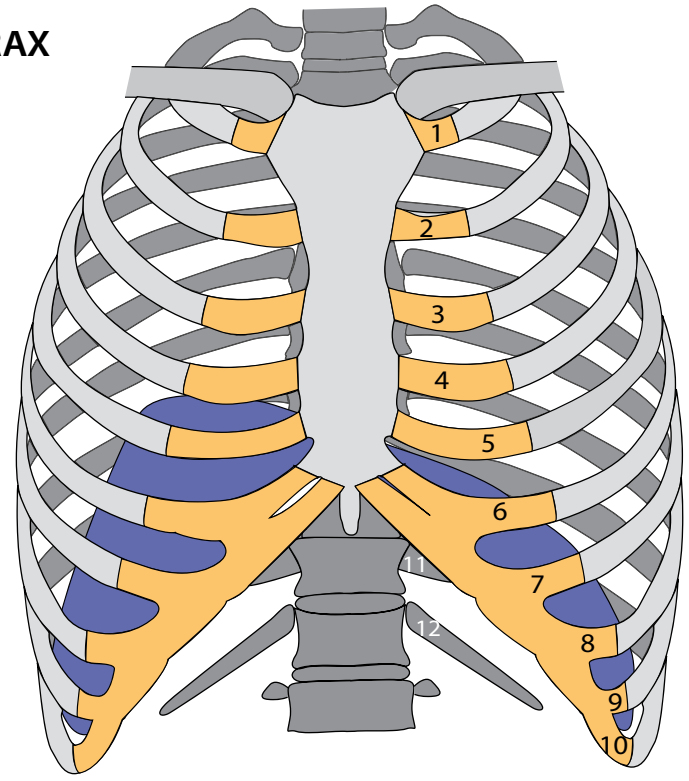
Access to thoracic aorta: Through the left chest (left thoracotomy)
Access to oesophagus: Through right chest (right thoracotomy)
(Both of these are usually through the 5th intercostal space by stripping up the periosteum of the rib below and incising through the rib bed)
Thoraco-abdominal incision:

- For large access to upper abdomen or chest
- Through 9th intercostal space on either side
- 9th costal cartilage is usually excised
- The diaphragm is incised radially to avoid damaging its nerve

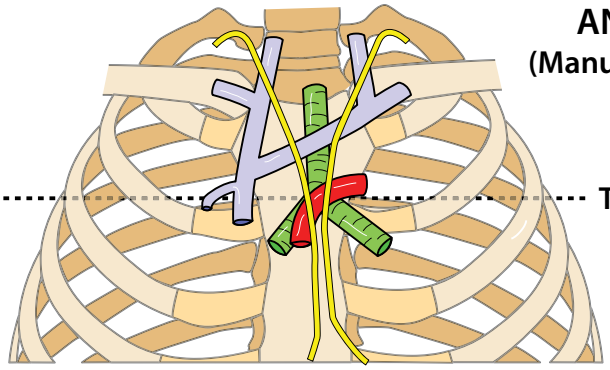
Pericardial aspiration: Insert needle just to left of xiphoid
Pericardial window: Through left thoracotomy; 5th costal cartilage excised; Pericardial flap cut
Heart transplantation: Via median sternotomy; En bloc - aorta, pulmonary trunk, both atriae; SVC, IVC, SA node are all left in situ
Aspiration of pleural cavity: Siting of drain in 4th space in anterior axillary line

EXTENT OF LIVER IN THORAX

On the right it extends as far as the 4th or 5th rib and extends inferiorly to the 10th ribs

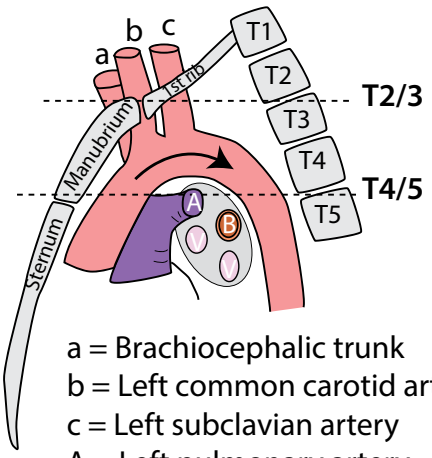


ANGLE OF LOUIS
(Manubriosternal junction)



- Manubiosternal junction
- Division of superior and inferior mediastinum
- Second costal cartilage
- Under surface of aortic arch
- Bifurcation of pulmonary artery
- Bifurcation of trachea
- Ligamentum arteriosum
- Left recurrent laryngeal nerve
- Cardiac plexuses
- Azygos arch/vein enters superior vena cava
- Pleura initially meet superiorly

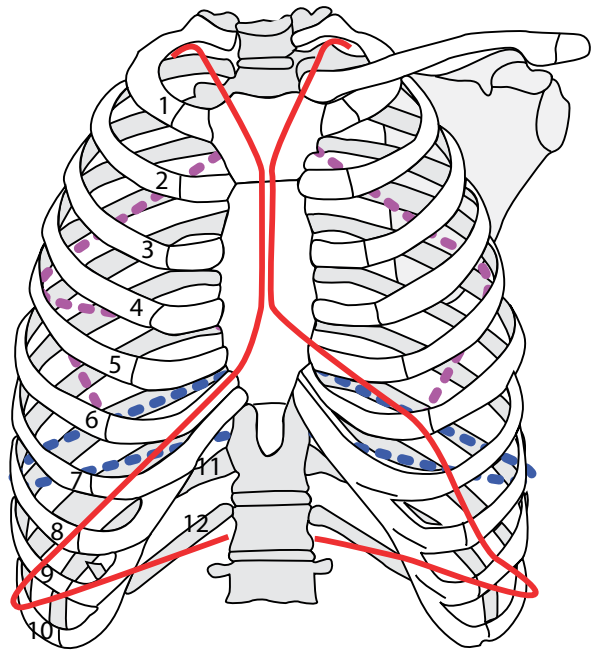
Vertebral bodies of T3 and T4 lie posterior to the manubrium



a = Brachiocephalic trunk
b = Left common carotid artery
c = Left subclavian artery
A = Left pulmonary artery
B = Left bronchus
V = Left pulmonary veins
T2/3 = Suprasternal notch
T4/5 = Sternomanubial junction

The direction of the arch is mostly posterior but also to the left

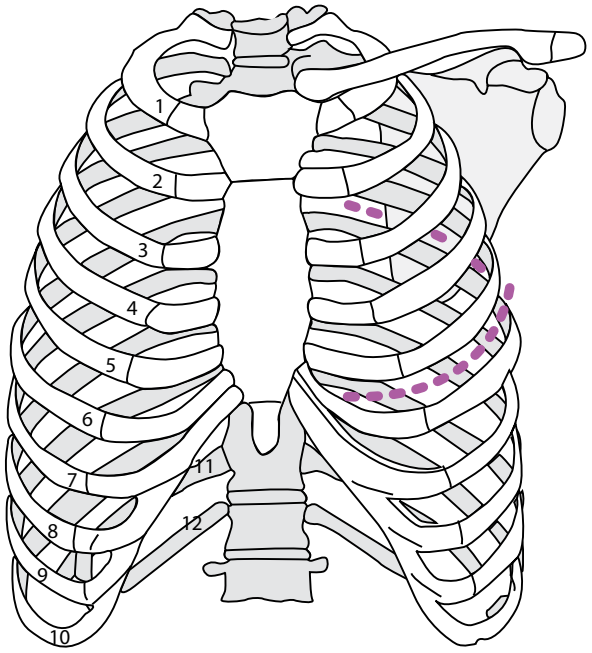
SURFACE MARKINGS OF PLEURA AND LUNGS



Pleura 2-4-6-8-10-12
Continuous Red line, starting 1" (2.5cm) above mid point of medial 1/3 of clavicle. Meet in midline at rib 2, left side then diverges at rib 4 to make room for the heart, whilst right continues parasternally to rib 6. Both cross rib 8 in the mid-clavicular line, then rib 10 in the mid-axillary line. Both reach posterior chest just below rib 12.

Lungs 2 less than pleura
Blue dotted lines indicate lower extension of lungs in expiration. Below ribs 6, the lungs extend to 2 rib spaces less than the pleura.

Fissures 3-6-4-5
(purple dotted lines)
Oblique: spine of T3 vertebra to rib 6 anteriorly along medial border scapula
Horizontal (on R only): rib/costal cartilage 4 to rib 5 in mid-axillary line.



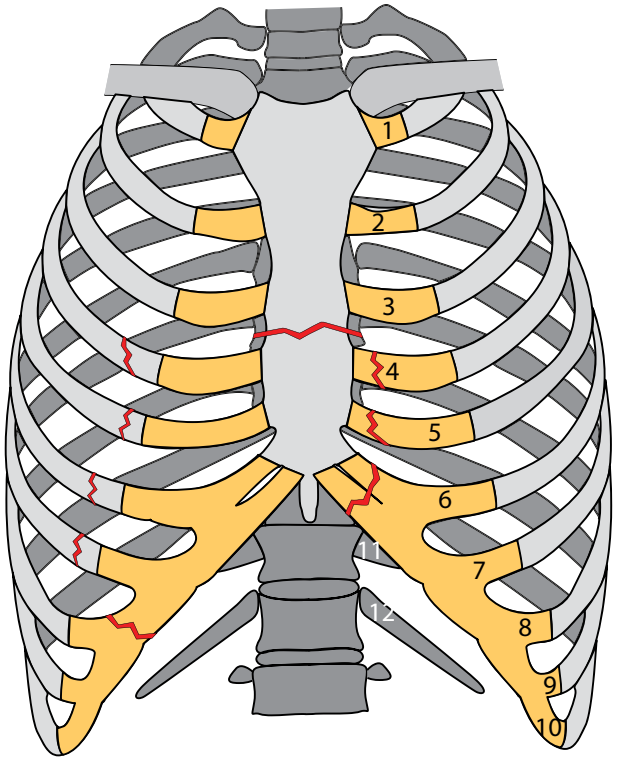
EMERGENCY THORACOTOMY

5th Intercostal space

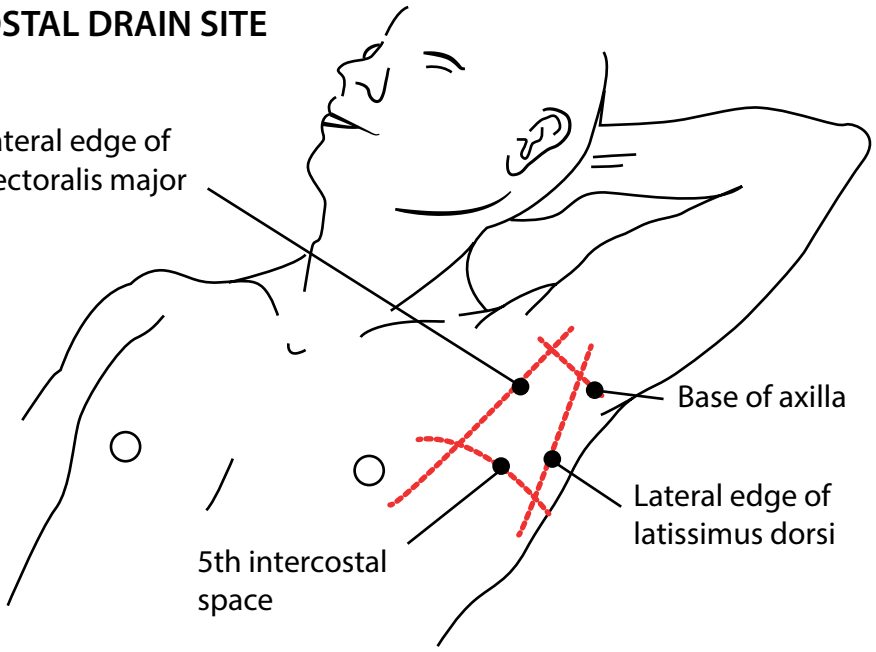
FLAIL CHEST

Multiple chest wall fractures

During respiration the flail (detached) segment moves paradoxically - inwards when it should be expanding outwards and vice versa

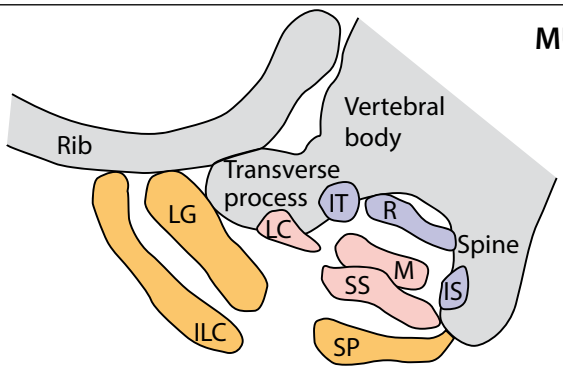


INTERCOSTAL DRAIN SITE



Avoid mid-axillary line so as not to damage long thoracic nerve

MUSCLES OF THE BACK 1

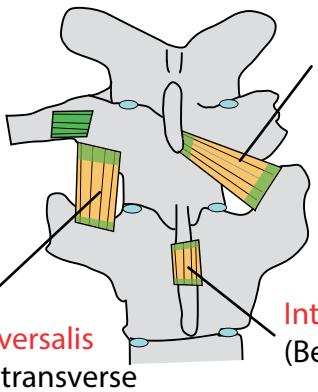


Arranged in three layers with three muscles on each layer. All supplied by posterior primary rami

SUPERFICIAL LAYER
- Iliocostalis (ILC)
- Longissimus (LG)
- Spinalis (SP)

INTERMEDIATE LAYER
- levator costarum (LC)
- Semispinalis (SS)
- Multifidus (M)

DEEP LAYER
- Interspinalis (IS)
- Intertransversalis (IT)
- Rotatores (R)



Rotatores (Spine to transverse process, in thorax only)

Interspinalis (Between spines)

Intertransversalis (between transverse processes)

MUSCLES OF THE BACK 2

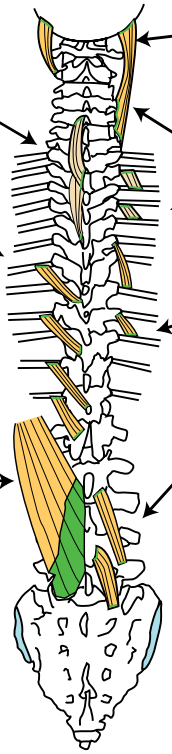
SUPERFICIAL LAYER

= **ERECTOR SPINAE**

Spinalis
Small, indefinite between spines

Iliocostalis
Mostly lateral, at all levels, angles of last 6 ribs to lumbosacral spines, transverse processes above and below, posterior tubercles in cervical region

Longissimus
Medial, thoracis, cervicis and capitis. From thoracolumbar fascia and lumbar transverse processes to several transverse processes above and mastoid process



Semispinalis

Capitis — Transverse processes C5-7, T1-6 to occiput

Cervicis — On multifidus, lower thorax to skull, transverse processes to spinal processes 6 above

Thoracis

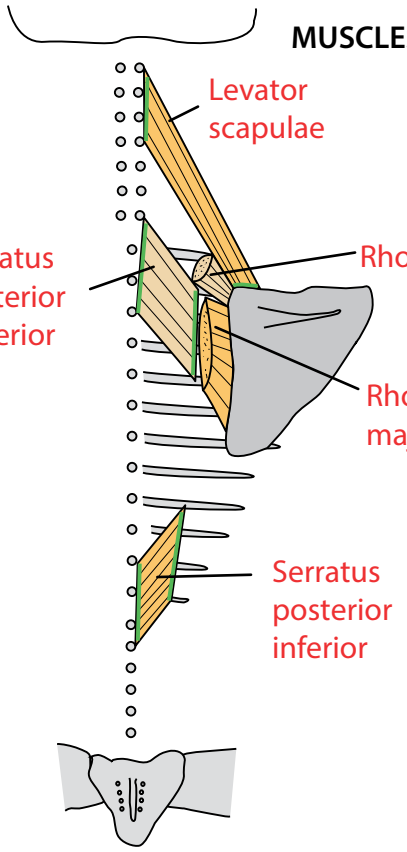
Levator costarum — 12 slips from transverse processes C7-T11 to posterior angle of rib below

Multifidus — Lamina to spinous process 2-3 above, from sacrum to C2

INTERMEDIATE LAYER

= **TRANSVERSOSPINALES**

MUSCLES OF THE BACK 3



COVERING MUSCLES
All supplied by ANTERIOR primary rami of spinal nerves except SPLENIUS

Splenius capitis (not shown).
Lower half ligamentum nuchae and spines C7,T1-3(or 4) to mastoid process and lateral 1/3 of superior nuchal line. Retracts head. Supplied by POSTERIOR rami of cervical nerves

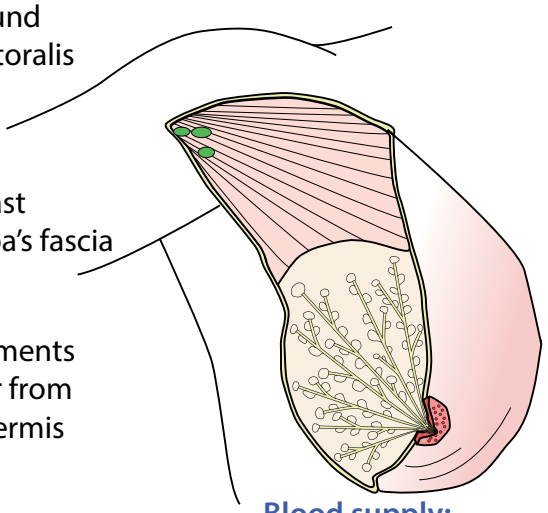
THE BREAST
(A modified sweat gland)

Lies on:
- Pectoralis major
- Serratus anterior
- External oblique (tail may curl round posterior to pectoralis minor)

Capsule:
- Posterior to breast
- Thickened Scarpa's fascia

Support:
- Suspensory ligaments of Astley Cooper from deep fascia to dermis

Structure:
- 15-20 lobes, each with 15 lactiferous ducts leading to ampulla under areola then to nipple



Position:
- On ribs 2-6 in midclavicular line
- Nipple in 4th intercostal space

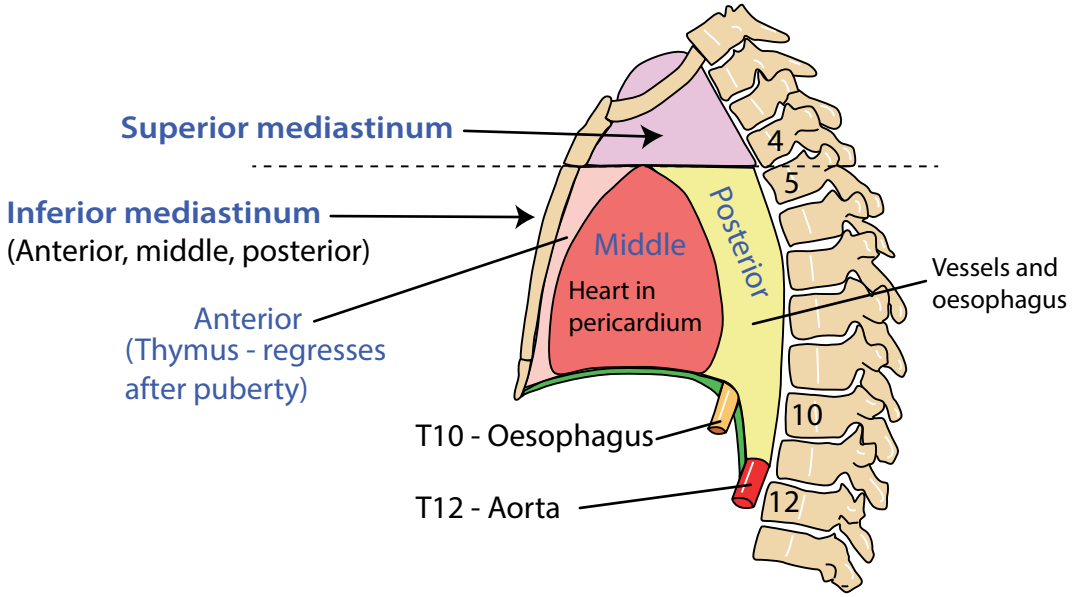
Lymphatics:
- Run deep to capsule in sub-mammary space to-
- Axilla (anterior, apical, central nodes)
- Infraclavicular nodes
- Internal thoracic nodes (parasternal)

NB: In disease lymph may go to:
- Other side
- Deep cervical
- Into peritoneum
- Inguinal

Blood supply:
- Internal thoracic (1st part subclavian)
- Lateral thoracic (2nd part axillary)
- Thoraco-acromial (2nd part axillary)
- Intercostal (internal thoracic)

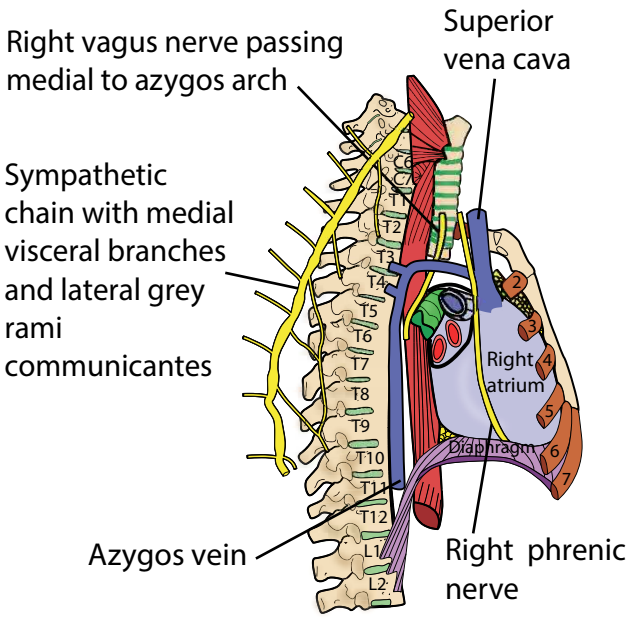
3.2 Mediastinum, Thoracic Inlet, Diaphragm and Lymphatics

DIVISIONS OF THE MEDIASTINUM

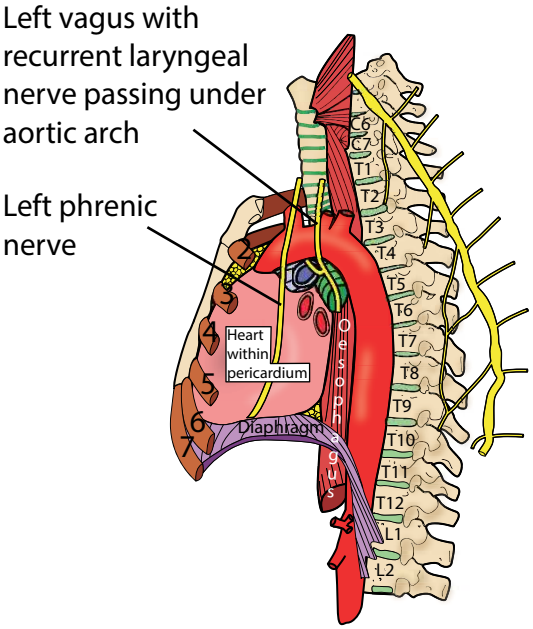


MEDIASTINUM: The area in the thorax that lies between the lungs, limited superiorly by the first rib and inferiorly by the diaphragm. Note that although the lungs reach up above the anterior aspect of the 1st rib, the mediastinum does not.

RIGHT LATERAL VIEW OF MEDIASTINUM



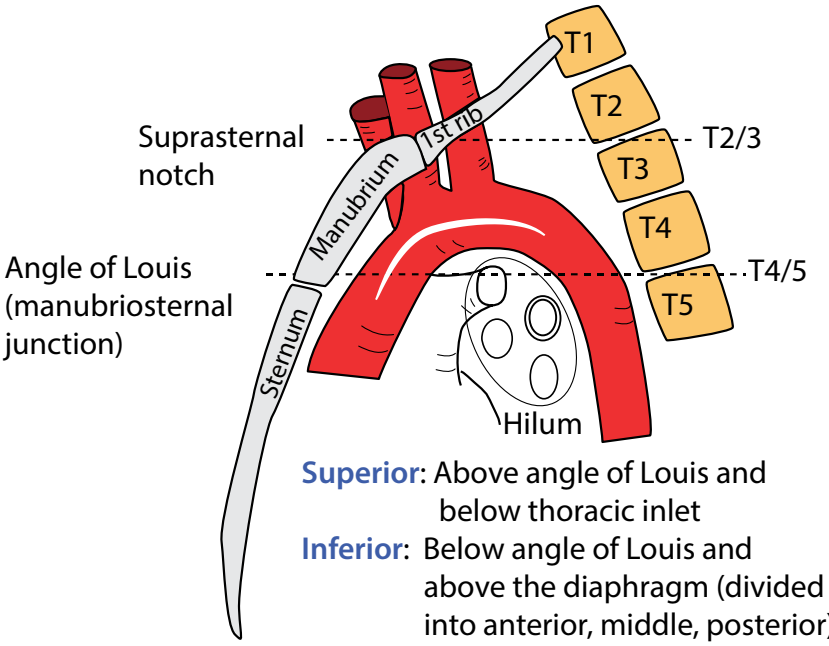
LEFT LATERAL VIEW OF MEDIASTINUM



Oesophagus is midline until to approaches the diaphragm when it moves anteriorly and to the left. It lies immediately posterior to the left atrium

MEDIASTINUM

The area in the thorax that lies between the lungs BUT does not extend above the first rib

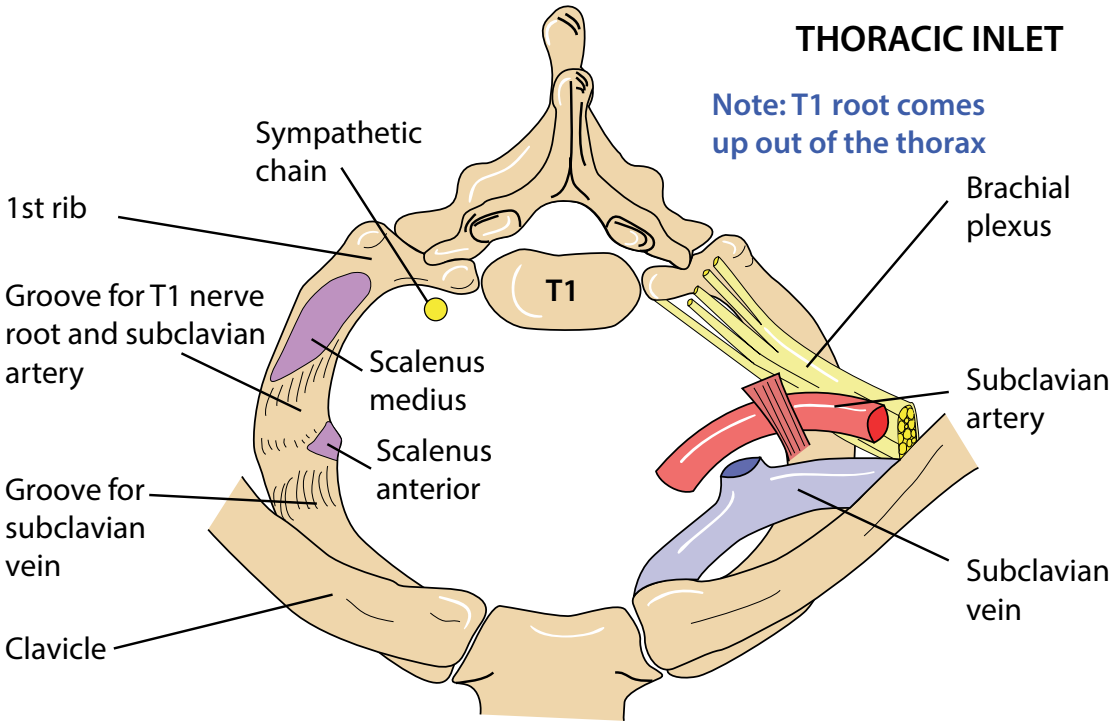


Superior: Above angle of Louis and below thoracic inlet

Inferior: Below angle of Louis and above the diaphragm (divided into anterior, middle, posterior)

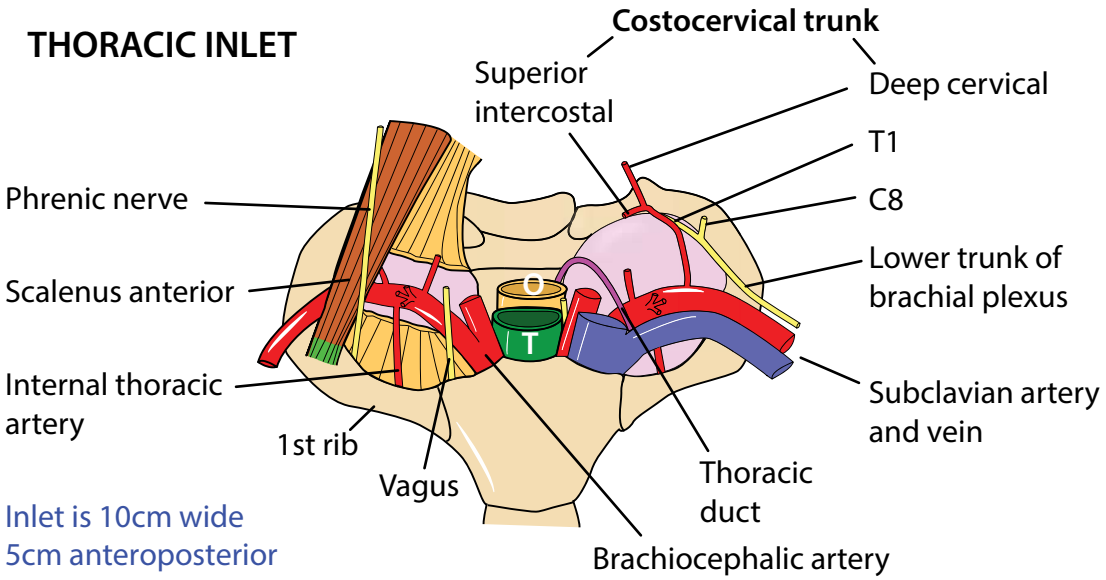
THORACIC INLET

Note: T1 root comes up out of the thorax



The thoracic inlet is made up of the T1 vertebral body, the first rib and its costal cartilage and the manubrium. The clavicle is not included.

THORACIC INLET



Dome of pleura is covered by suprapleural membrane (Sibson's fascia). Held up by scalenus minimis (pleuralis) from transverse process of C7 vertebra.
It extends 4cm above middle of medial third of clavicle and first rib, BUT NOT above neck of first rib

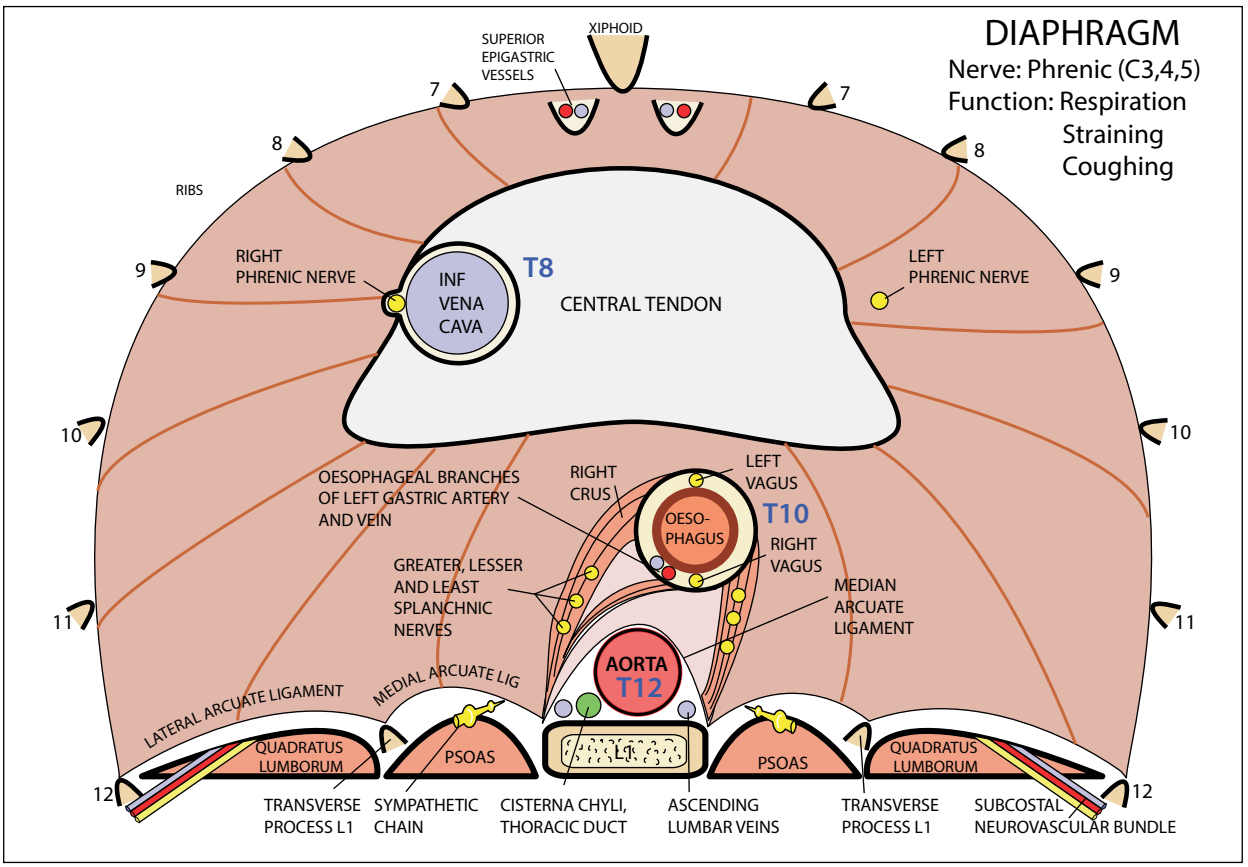
DIAPHRAGM - OPENINGS AND RELATIONS

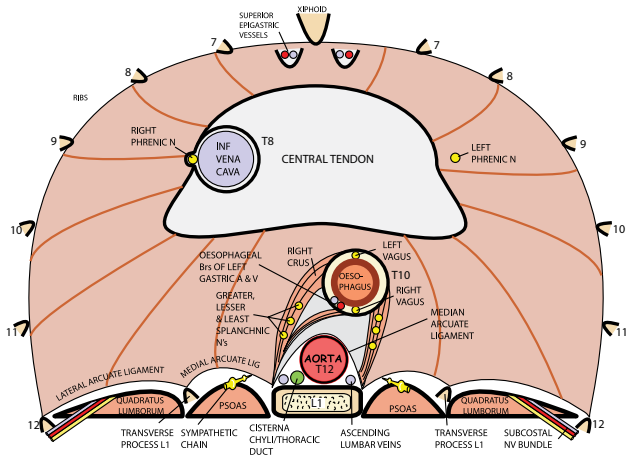
OPENINGS

Caval (T8): Inferior vena cava and right phrenic nerve
Left muscular dome (T8): Left phrenic nerve
Anterior hiatus (T9): Superior epigastric artery and vein
Oesophageal (T10): Oesophagus, left and right vagus nerves, oesophageal branches of left gastric artery and vein, lymphatics
Aortic (T12) (Strictly posterior to diaphragm): Aorta, azygos vein and hemiazygos vein (may pass through left crus), thoracic duct
Crura (T12): Greater, lesser and least splanchnic nerves
Posterior to medial arcuate ligament: Sympathetic chain
Posterior to lateral arcuate ligament: Subcostal nerve (T12), artery and vein

RELATIONS

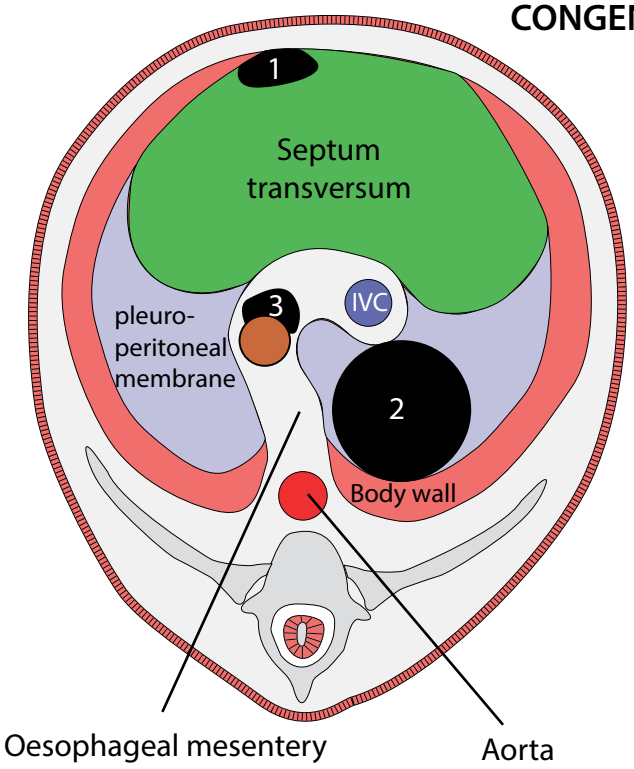
Right dome: Reaches 4th costal space (nipple) in expiration
Left dome: Reaches 5th rib in expiration
Superior: - Pericardium, basal lung segments
Inferior: - Right - liver, suprarenal, kidney
Left - stomach, suprarenal, kidney and spleen
Posterior: - Aorta, azygos veins, oesophagus, vagi, pleural folds





Origin: Vertebral - Right crus (L1,2,3), left crus (L1,2), 5 arcuate ligaments
Sternal - Xiphoid, Costal - Ribs and costal cartilages 7-12
Insertion: Central tendon (trefoil-1 anterior and 2 posterior, fused with pericardium)
Action: Inspiration - 70% at rest (5cm of movement). Less % on exertion (10cm movement)
Straining - Outlet of chest is fixed and larynx closed to raise intra-abdominal pressure
Nerve supply: Phrenic nerves - C3,4,5. 1/3 sensory, 2/3 motor. Diaphragm has no other motor supply
Blood supply: Outer - lower 5 intercostals and subcostal arteries. Inner - Inferior phrenic from aorta, musculophrenic/pericardiacophrenic from internal thoracic

CONGENITAL DIAPHRAGMATIC HERNIAS



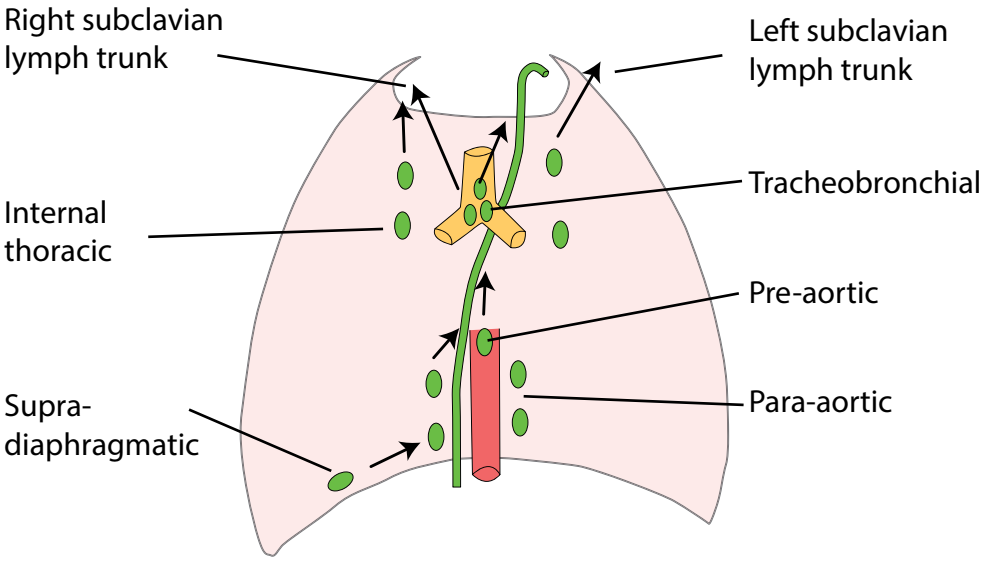
Development of diaphragm from:

1. Septum transversum
2. Pleuroperitoneal membrane
3. Oesphageal mesentery
4. Body wall

Sites of hernias:

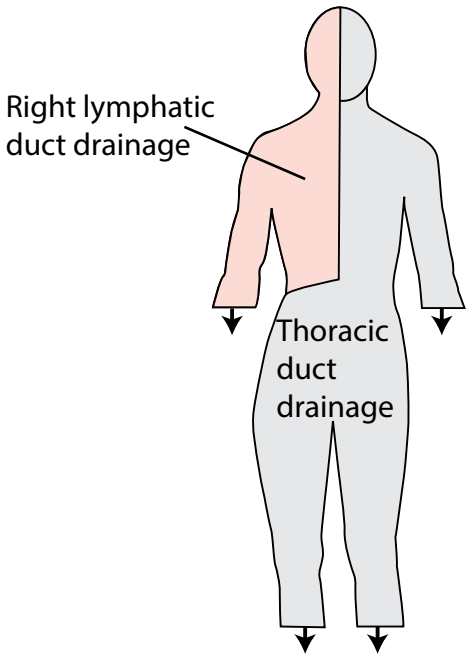
1. Foramen of **M**orgagni (Parasternal - nearly "**m**idline")
2. Foramen of **B**ochdalek (at "**b**ack") (Pleuroperitoneal hernia)
3. Oesophageal hiatus
4. Dome of diaphragm (not shown)

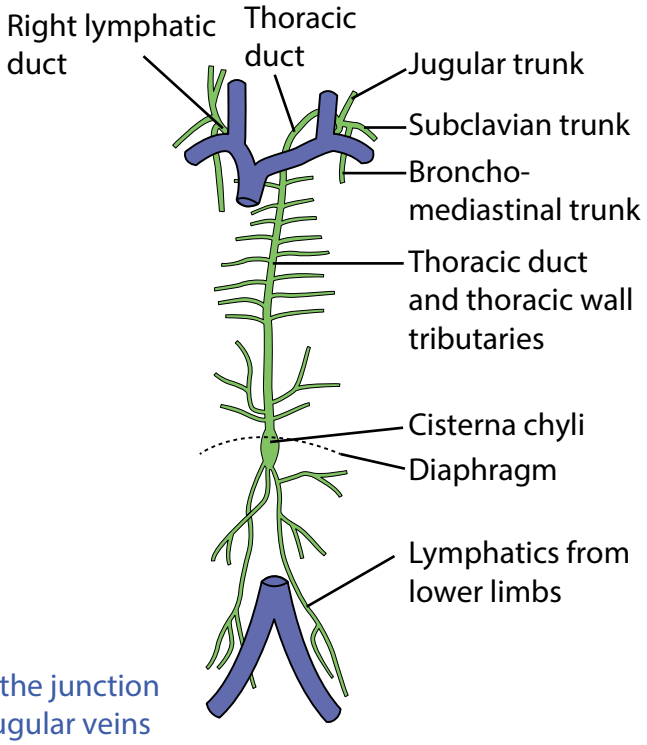
LYMPHATICS IN THE THORAX



Normal drainage from the breast is to anterior and posterior axillary, infraclavicular and internal thoracic groups of nodes. With pathological blockage from disease, the spread can to be to opposite side, cervical, peritoneal cavity, liver and occasionally to inguinal nodes.

LYMPHATIC DRAINAGE



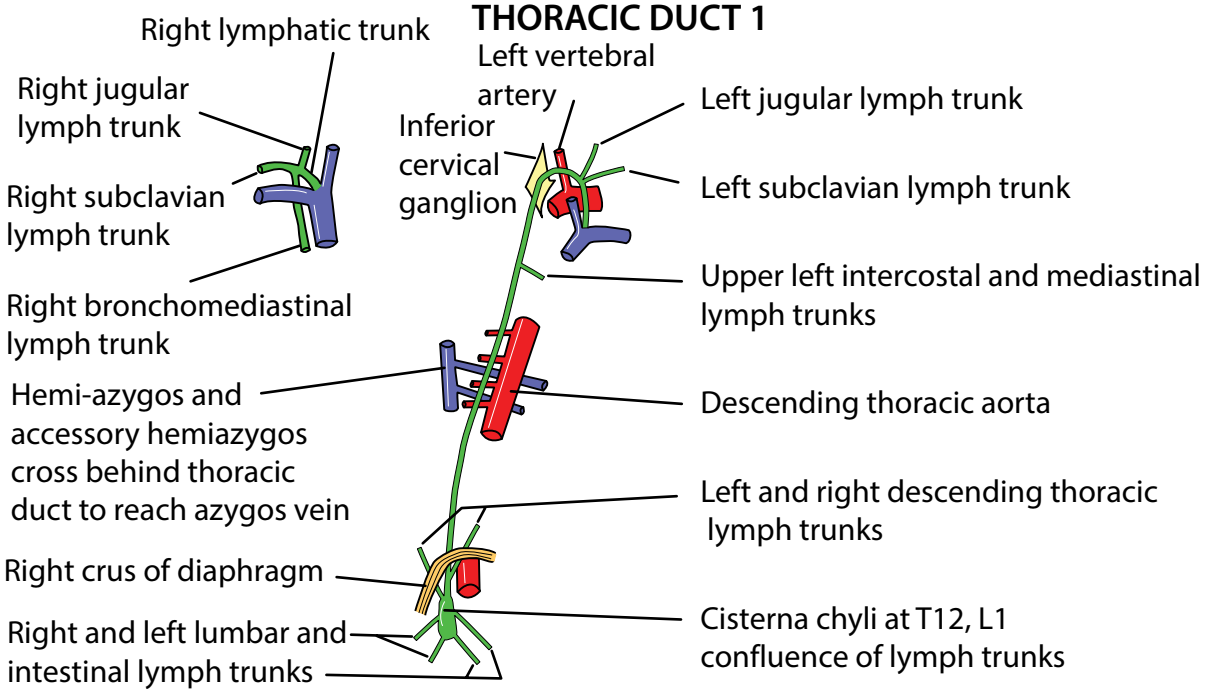


On each side lymph drains into the junction of the subclavian and internal jugular veins

THORACIC DUCT

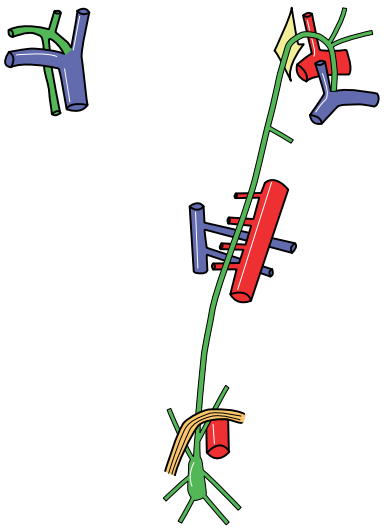
1. 45cm long (see also spinal cord, femur, vas, transverse colon, teeth to cardia)
2. Many valves in system
3. Drains all lymph below the diaphragm, left head/neck and left thorax
4. Commences at T12, ascends posterior to right crus; to right of aorta and oesophagus, then posterior to oesophagus
5. Crosses to left of midline at T5
6. Lies superficial (anterior) to posterior intercostal arteries and the crossing azygos systems; over the dome of the pleura; over (anterior) to left vertebral and left subclavian arteries
7. Enters into confluence of left subclavian and left internal jugular veins

THORACIC DUCT 1



Lies superficial (anterior) to posterior intercostal arteries and the crossing azygos systems, over the dome of the pleura, over (anterior) to left vertebral and left subclavian arteries, into confluence of left subclavian and left internal jugular veins.

THORACIC DUCT 2



Several terminal branches. Many valves in the system

↑

Drains all lymph below diaphragm, left head/neck and left thorax

↑

45cm long (similar in length to the spinal cord, femur, vas, transverse colon and distance between teeth and oesophagogastric junction)

↑

Commences at T12, ascends behind right crus, to right of aorta and oesophagus. Then crosses the midline behind the oesophagus at T5

3.3 Heart and Pericardium

HEART

BORDERS:

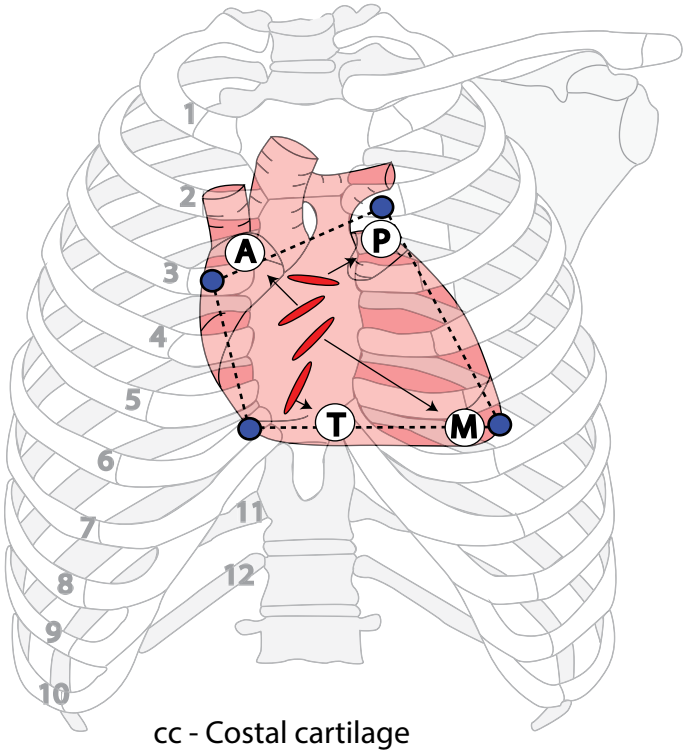
2cc - 3cc - 6cc - 5 1/2

VALVES:

P - A - M - T

AUSCULTATION:
P - 2L (parasternal space)
A - 2R (parasternal space)
M - 5L (mid clavicular line)
T - Lower left sternal border

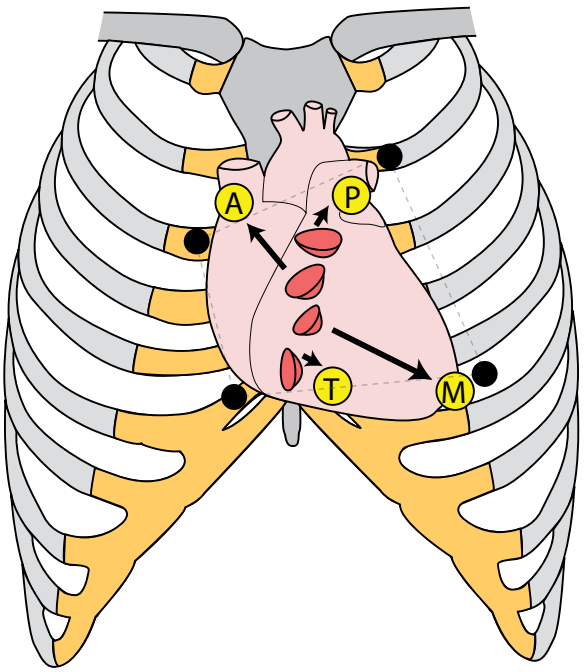
As the valves open and close they produce sounds that appear to be transmitted in the direction of the flow of blood. Thus, by picturing the heart and the positions of the four valves it is easy to work out the likely points for maximal audibility of the sounds.



cc - Costal cartilage

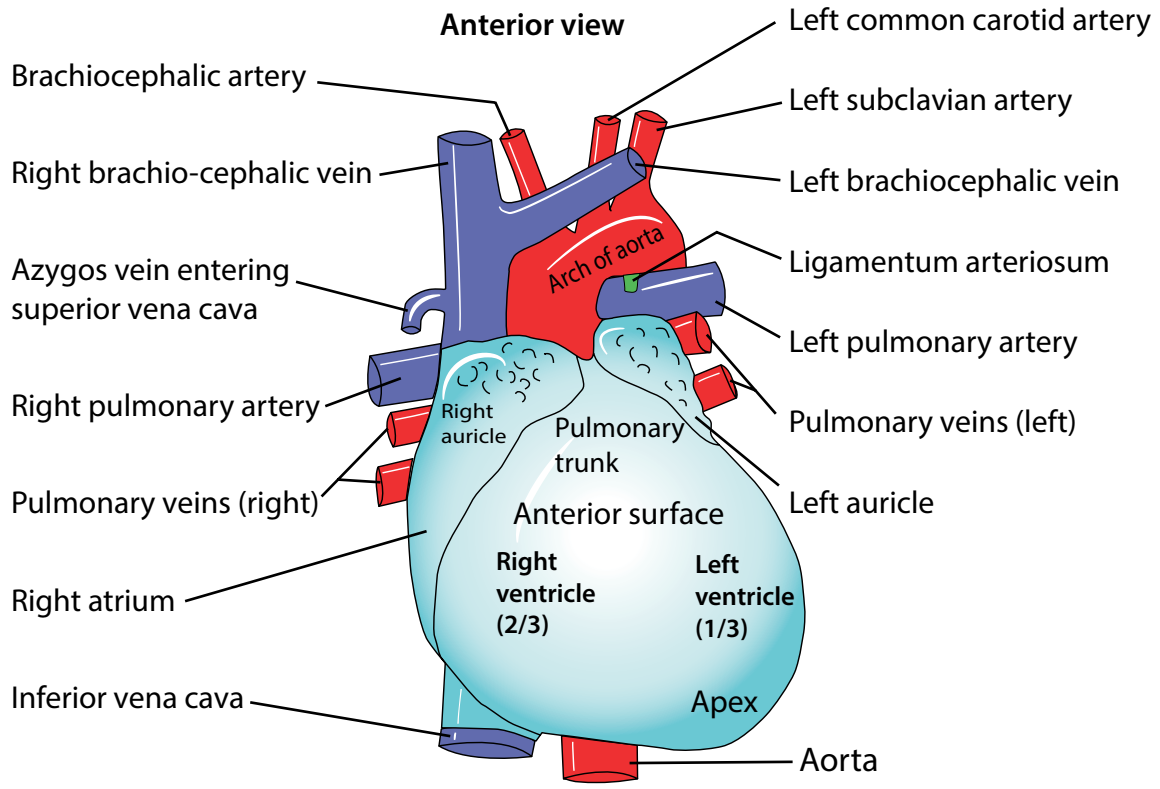
HEART, HEART VALVES AND SITES OF AUSCULTATION

Surface anatomy: Normal sized heart in thorax. **Borders:** Anticlockwise starting from upper left: Left 2nd costal cartilage to right 3rd costal cartilage to right 6th costal cartilage to left 5th intercostal space in the mid-clavicular line (summary 2-3-6-51/2)
Auscultation: As the valves open and close they produce sounds that are transmitted in the direction of blood flow. The 4 valves lie behind the sternum. Sounds are transmitted as follows:
PULMONARY - 2nd left intercostal space, parasternally.
AORTIC - 2nd right intercostal space, parasternally.
MITRAL - 5th left intercostal space, midclavicular line (apex).
TRICUSPID - To right or over lower sternum

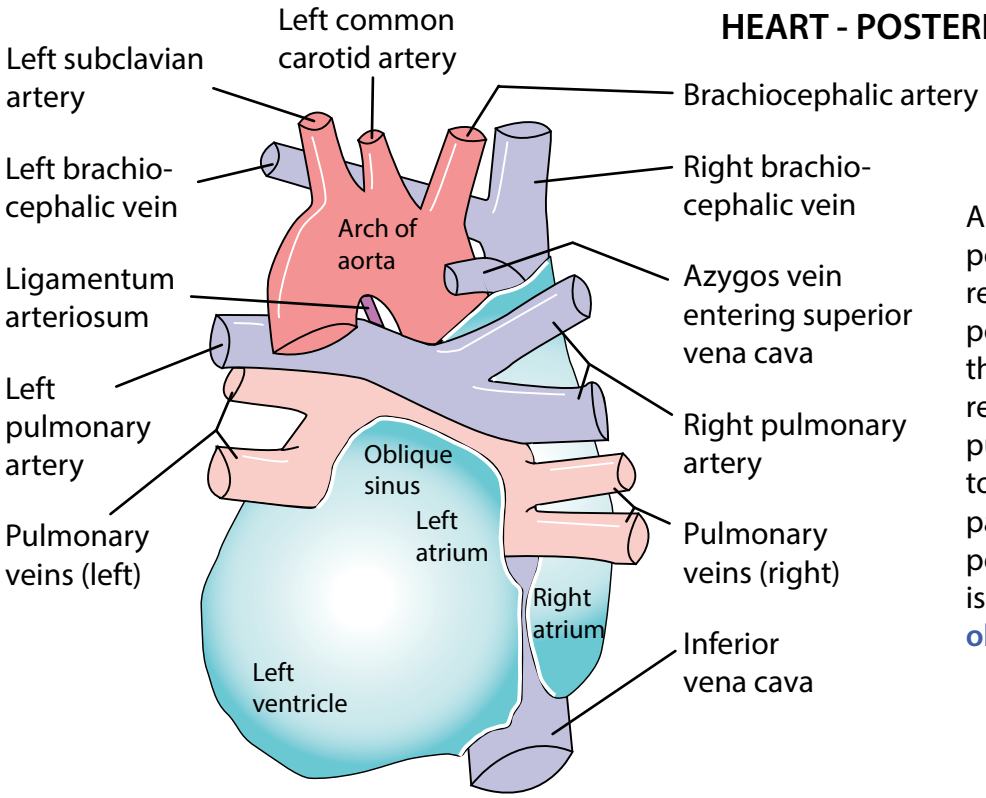


BORDERS OF HEART

Anterior view

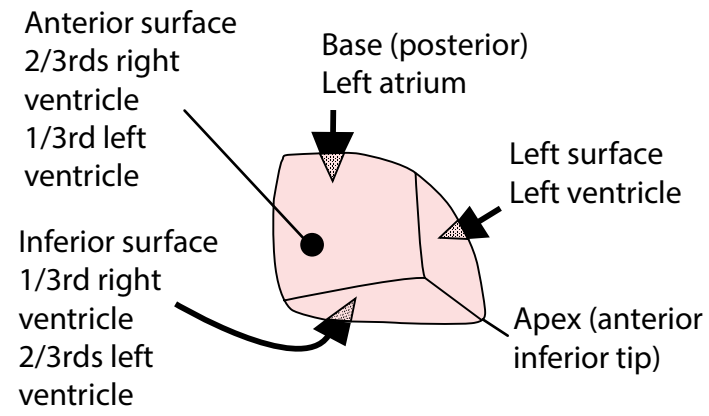


HEART - POSTERIOR VIEW



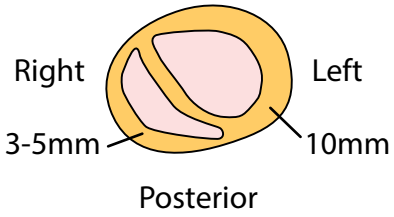
As the visceral pericardium reaches up posteriorly on the left atrium it reflects off the pulmonary veins to become the parietal pericardium. This is the site of the **oblique sinus**

HEART - SURFACES AND SEPTUM



- Midline in middle mediastinum
- Valved muscular pump
- Size of a fist - 300g
- Cone shaped
- Surfaces: see figure but note that base is the posterior surface (left atrium)
- Muscle: Hypertrophies but no increase in number of fibres
- Approximate number of beats per year: 42 million

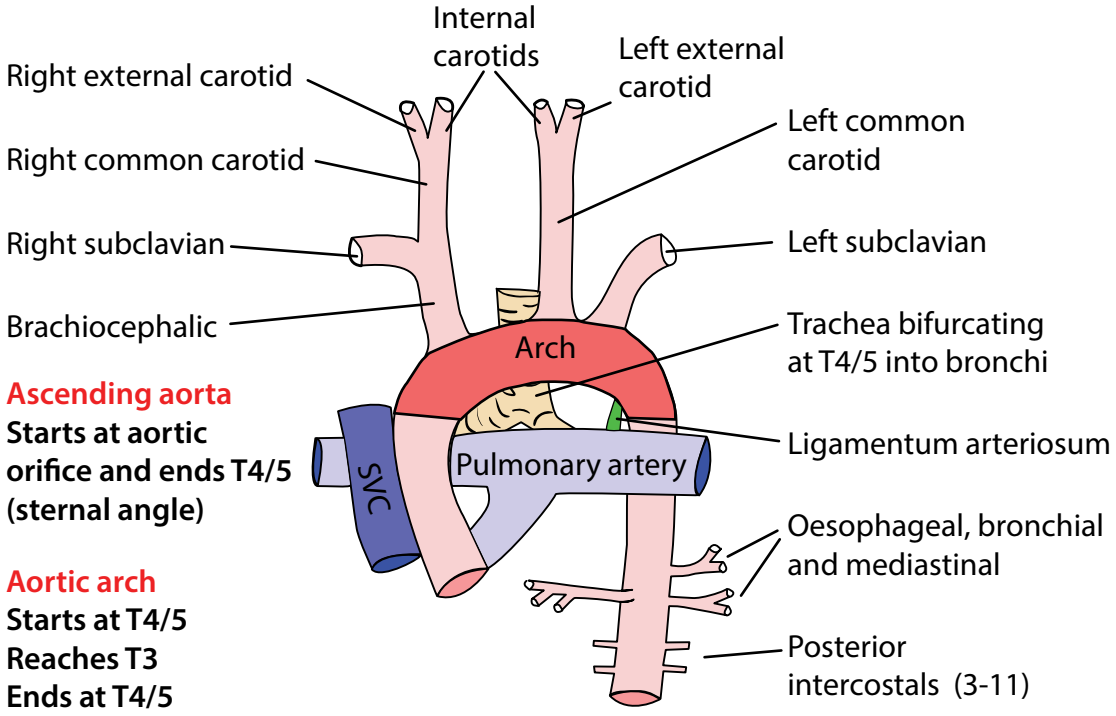
INTERVENTRICULAR SEPTUM



Septum

- Bulges to right
- Lies vertically, obliquely and almost in coronal plane
- Attaches to AV rings

AORTIC ARCH AND ARTERIAL BRANCHES



Ascending aorta
Starts at aortic orifice and ends T4/5 (sternal angle)

Aortic arch
Starts at T4/5
Reaches T3
Ends at T4/5

Image is semi-diagrammatic

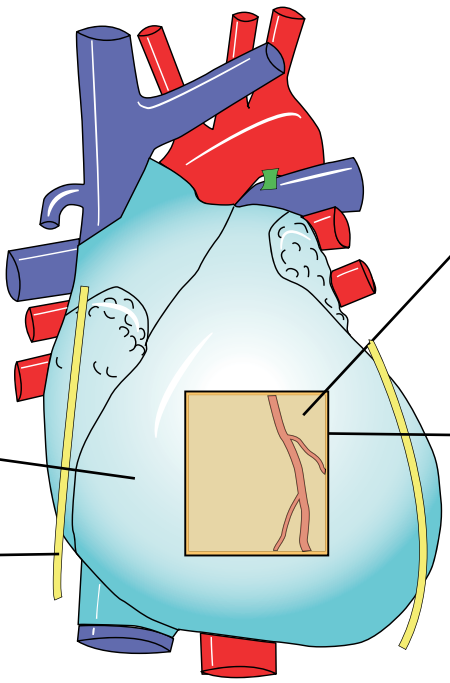
HEART - PERICARDIUM

PERICARDIUM

- Outer layer - Fibrous
  Blends with adventitia of aorta, pulmonary trunk, superior vena cava (not inferior vena cava) and central tendon of diaphragm
- Inner layer - Serous
  - Visceral
  - Parietal
- **Blood:** pericardiacophrenic and internal thoracic
- **Nerve:** Phrenic to fibrous and parietal serous layers
  Sympathetic for pain and muscles and vessels of heart
  General visceral afferents (or maybe nil) to visceral layer

PERICARDIUM

Prevents: Excessive movement and rapid overfilling
Holds: The heart in the mediastinum
Gives: Protection and lubrication

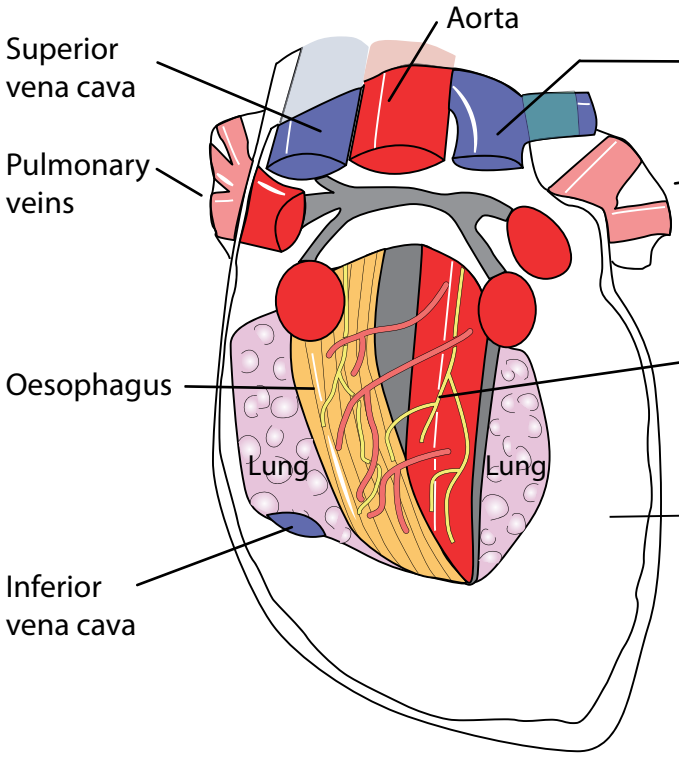


Visceral layer
Sensory: No somatic but probably general visceral afferent in parasympathetics (vagus) or sympathetics

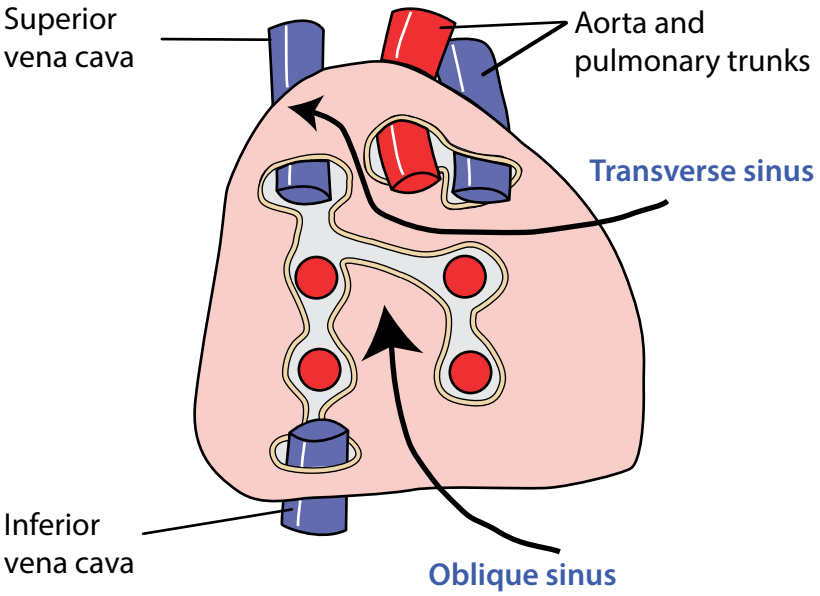
Fibrous layer and parietal serous layer
Somatic Sensory: Phrenic nerve

The fibrous and parietal serous layers have been cut away to expose the visceral layer of the pericardium

PERICARDIUM - HEART REMOVED WITH VISCERAL LAYER



PERICARDIAL SINUSES



SINUSES OF PERICARDIUM

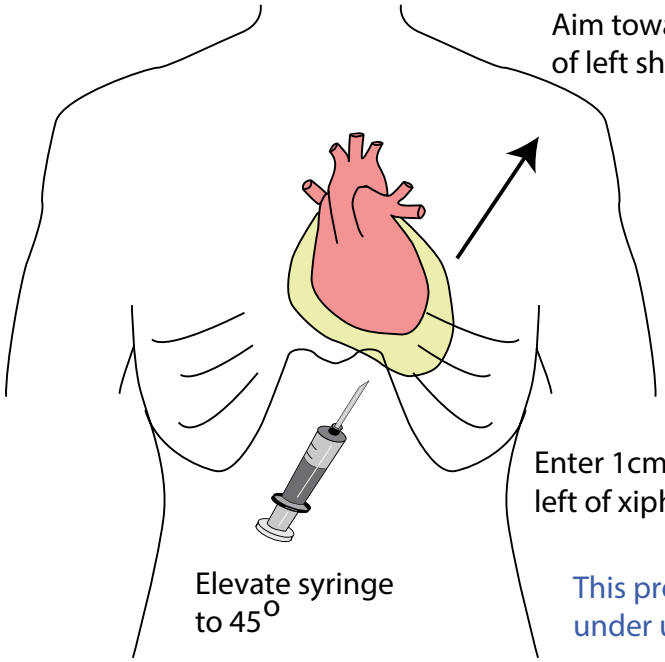
Transverse

Lies between the pulmonary artery and aorta anteriorly, and pulmonary veins and superior vena cava posteriorly

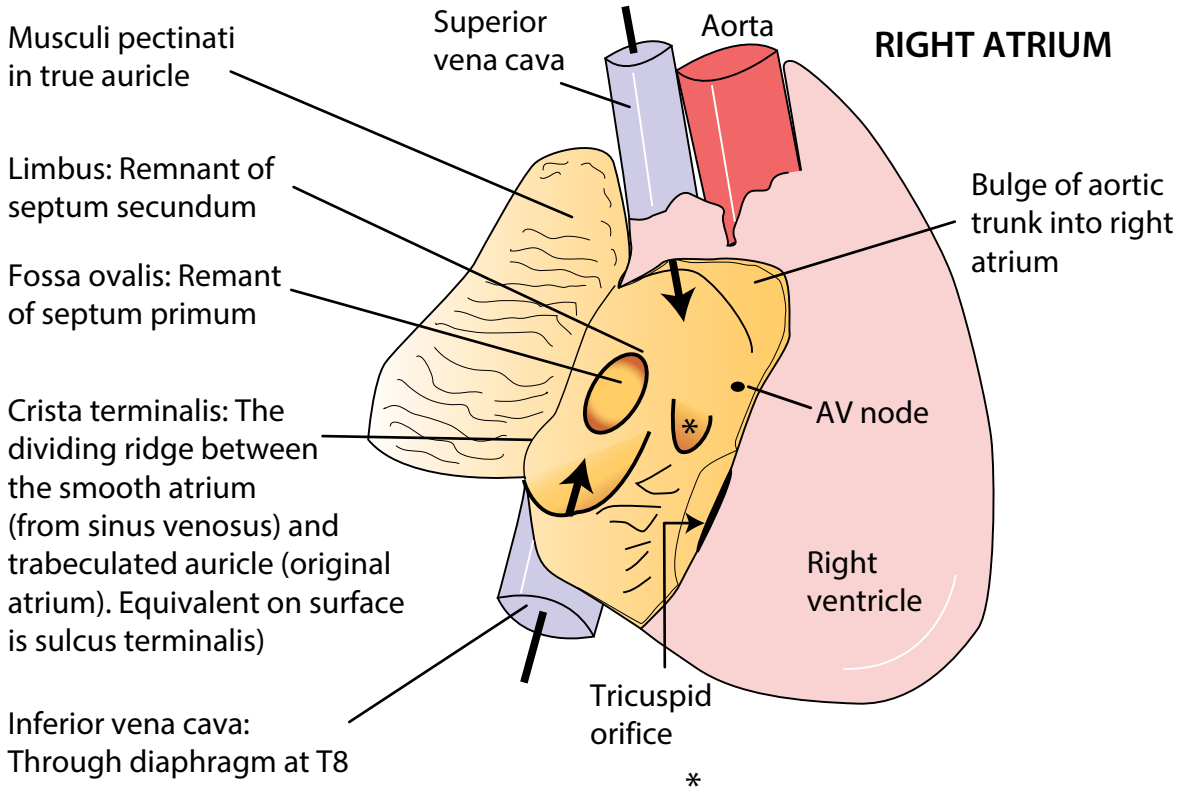
Oblique

This is a pouch of pericardium between the pulmonary veins at the base of the heart where the visceral pericardium is reflected off the vessels to become the parietal pericardium

ASPIRATION OF PERICARDIAL EFFUSION



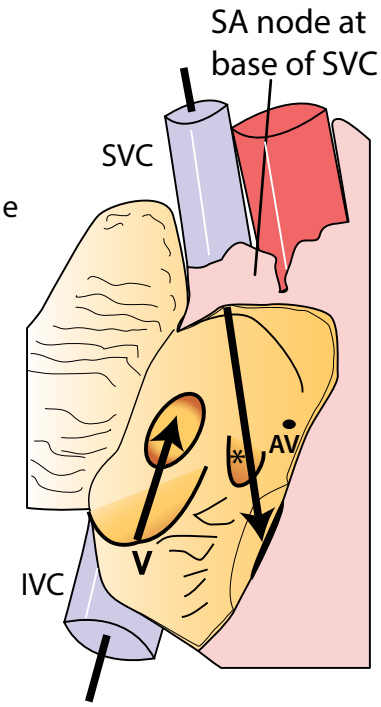
RIGHT ATRIUM



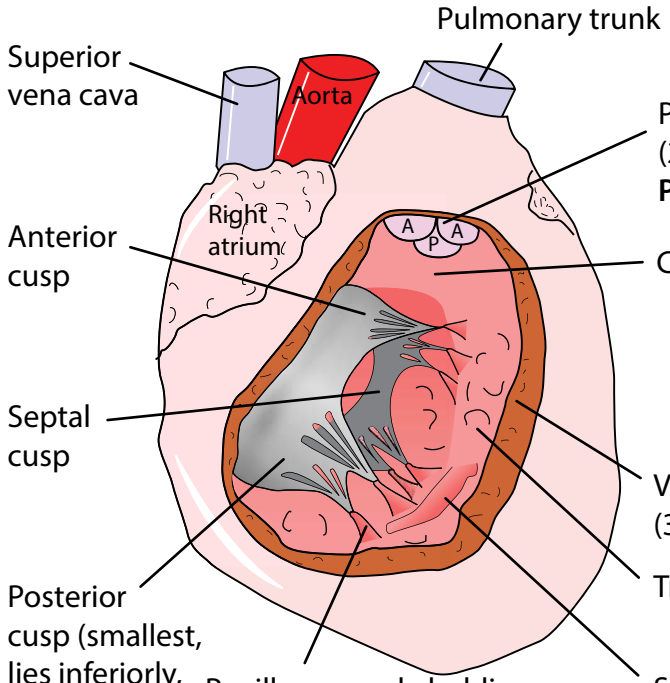
FETAL SHUNTING

In the fetus oxygenated blood passing up the inferior vena cava (IVC) is diverted by the **"valve of the IVC" (V)** into the foramen ovale and hence to the left atrium. Blood returning via the superior vena cava (SVC) passes down into the right ventricle

Opening of the coronary sinus (*)
Lies between the opening of the inferior vena cava and the atrioventricular orifice. Protected by a small valve which prevents regurgitation during atrial contraction. Between this orifice and the septal cusp of the tricuspid valve lies the atrioventricular node (AV)



HEART - RIGHT VENTRICLE



Pulmonary valve
(2 anterior, 1 posterior cusps)
PAPA: Pulmonary, **A**nterior, **P**osterior, **A**nterior

Conus arteriosus (infundibulum)

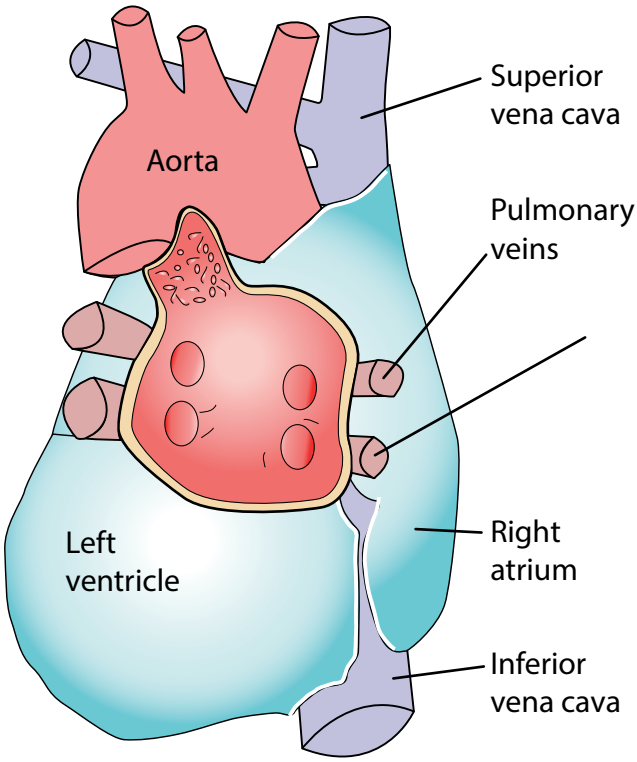
TRICUSPID VALVE
Anterior, septal and posterior. Attached to fibrous AV ring. Admits tips of 3 fingers

Ventricular wall (3-5mm thick)

Trabeculae carneae

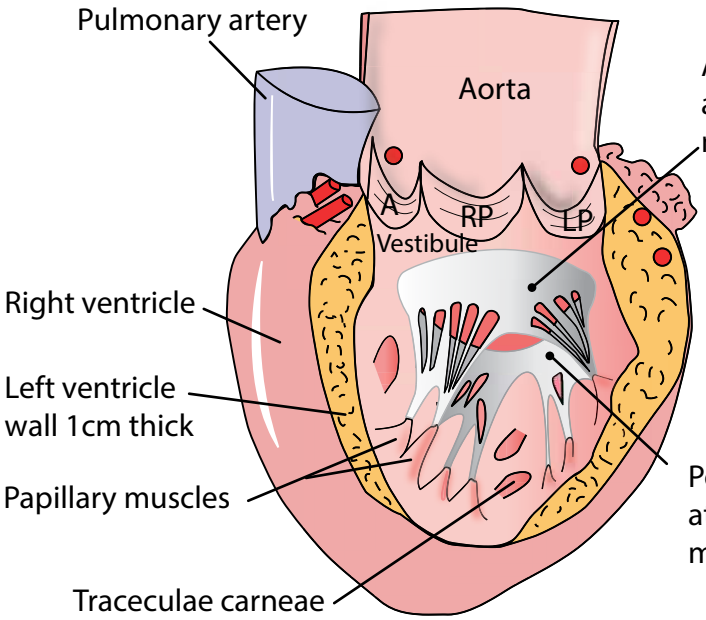
Septomarginal trabecula (moderator band - branch from right bundle)

HEART - LEFT ATRIUM



Base of heart(posterior surface). The left atrium is opened to show its smooth walled interior, apart from the musculi pectinati of the auricle. Four large, valveless pulmonary veins drain into it. On the interatrial wall there is a oval, thin area which is the left side of the fossa ovalis of the right atrium

HEART - LEFT VENTRICLE



Anterior cusp of mitral valve attached to anterior papillary muscle via chordae tendineae

MITRAL VALVE (Bishop's mitre)

- Anterior cusp is larger, septal and thicker
- Posterior is smaller and has 3 scallops
- Admits the tips of 2 fingers
- Attached to fibrous AV ring

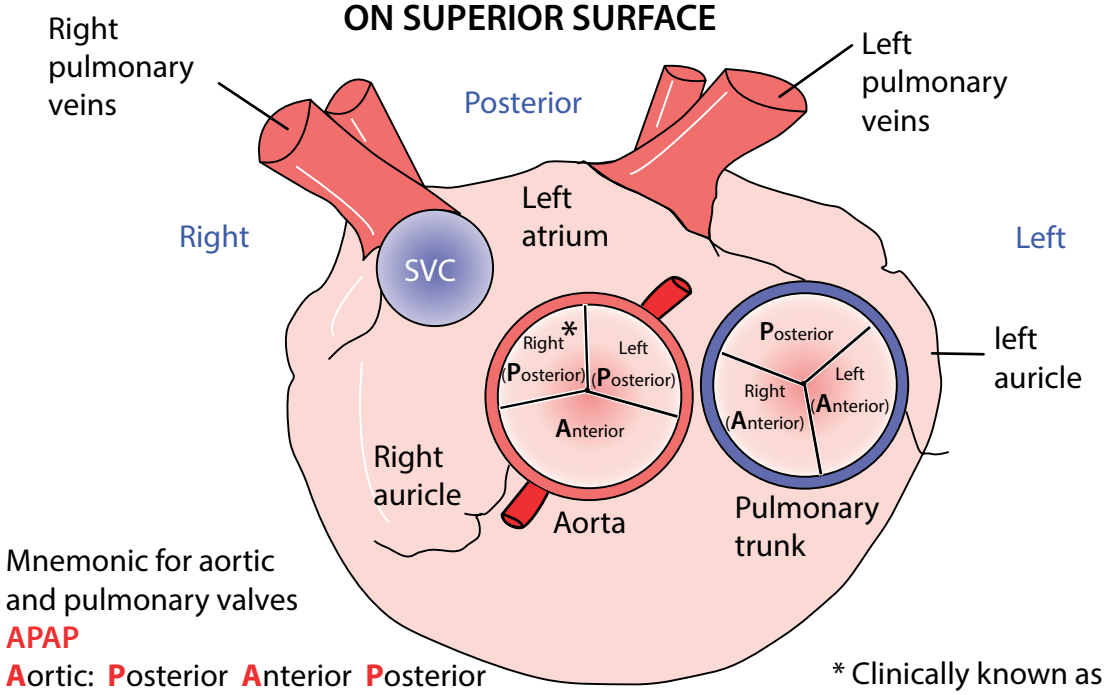
Posterior cusp of mitral valve attached to posterior papillary muscle via chordae tendineae

A: Anterior cusp and sinus (opening of right coronary artery)

RP: Right posterior (non-coronary) cusp and sinus

LP: Left posterior cusp and sinus (orifice of left coronary artery)

HEART - LOOKING DOWN ON SUPERIOR SURFACE



Mnemonic for aortic and pulmonary valves

APAP

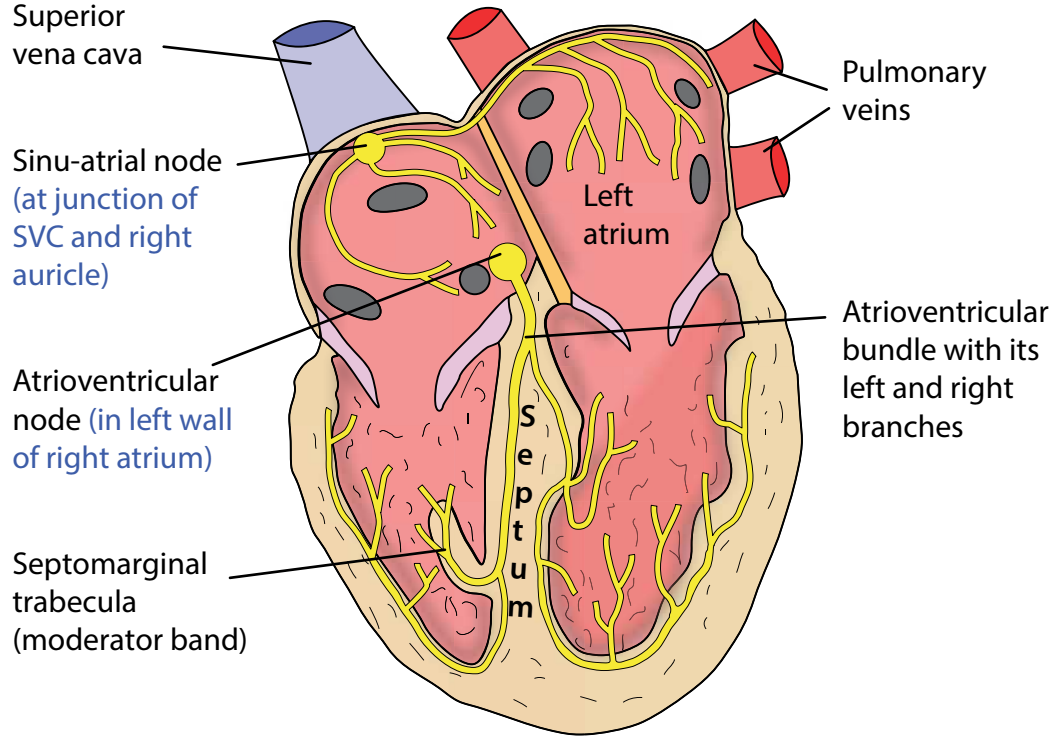
Aortic: **P**osterior **A**nterior **P**osterior

PAPA

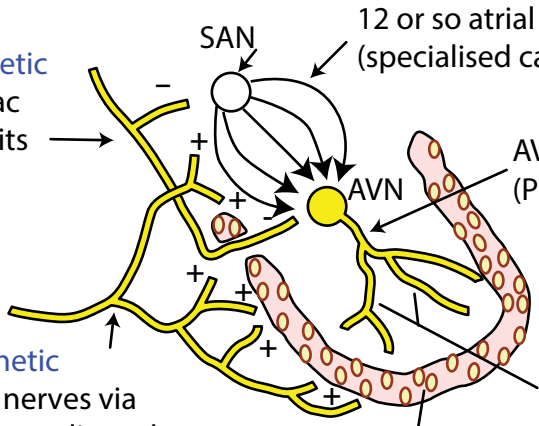
Pulmonary: **A**nterior **P**osterior **A**nterior

* Clinically known as non-coronary cusp

HEART - ELECTRICAL SYSTEM 1

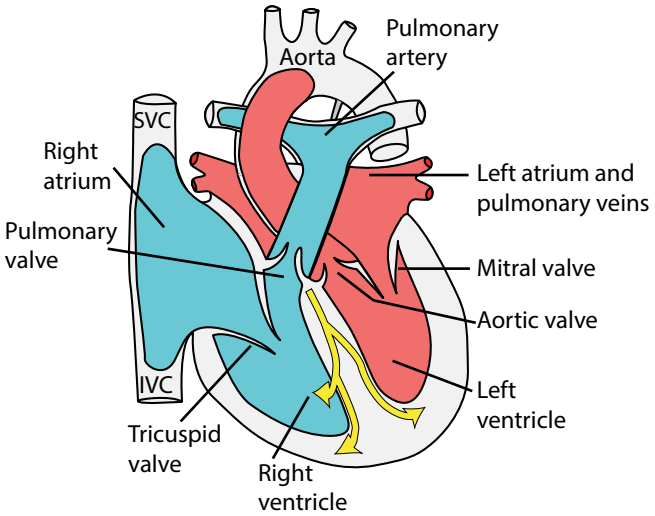


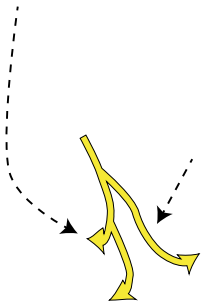
HEART - ELECTRICAL SYSTEM 2



BUNDLE OF HIS AND MODERATOR BAND

Branch of right bundle that enters the moderator band and then into the papillary muscle that extends from it

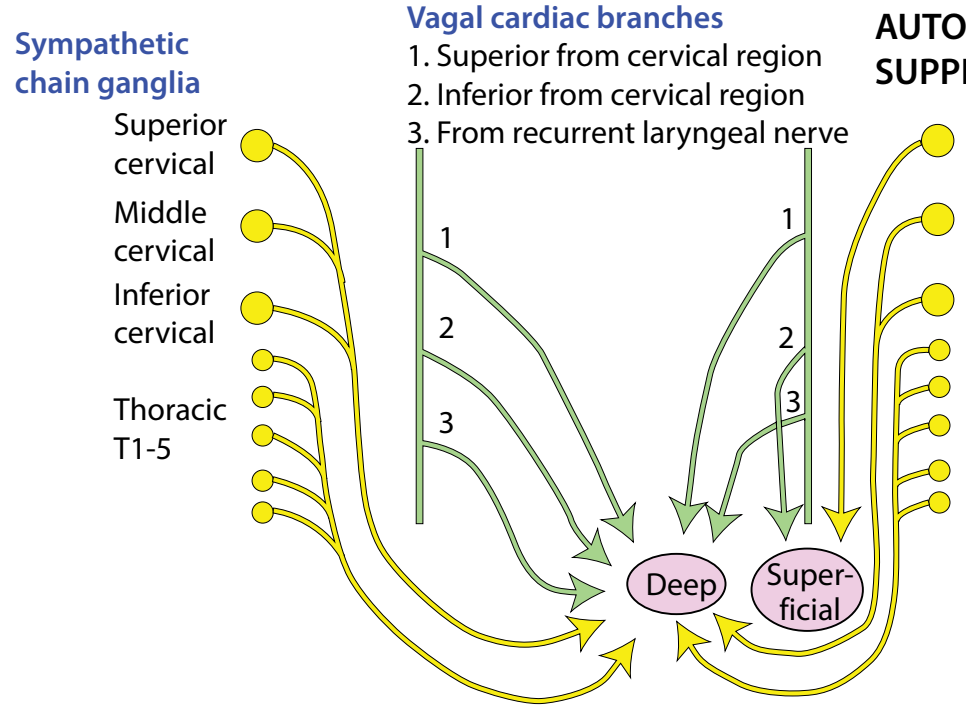




Left bundle running just beneath the endothelium of ventricle to start excitation from inferior aspect of chamber.

Right bundle running just beneath the endothelium of ventricle to start excitation from inferior aspect of chamber.

AUTONOMIC NERVE SUPPLY TO HEART

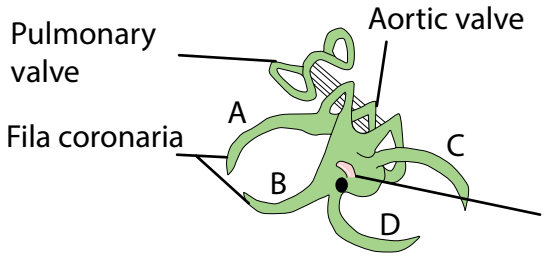


CARDIAC PLEXUSES

Deep plexus: lies to right of ligamentum arteriosum, inferior and medial to aortic arch

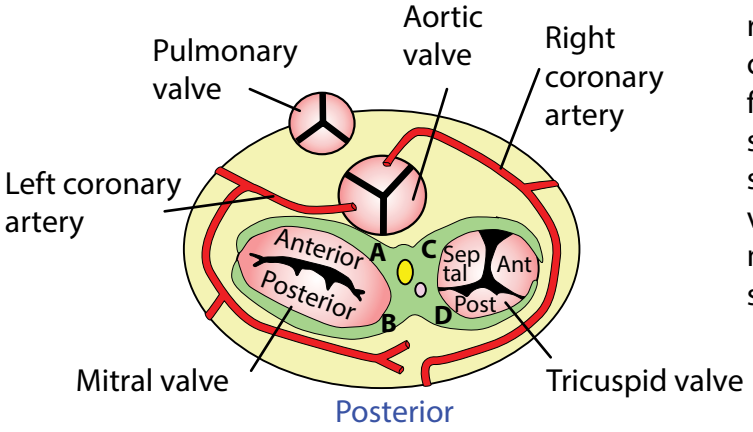
Superficial plexus: lies on aortic arch between phrenic and vagus nerves

HEART - FIBROUS SKELETON



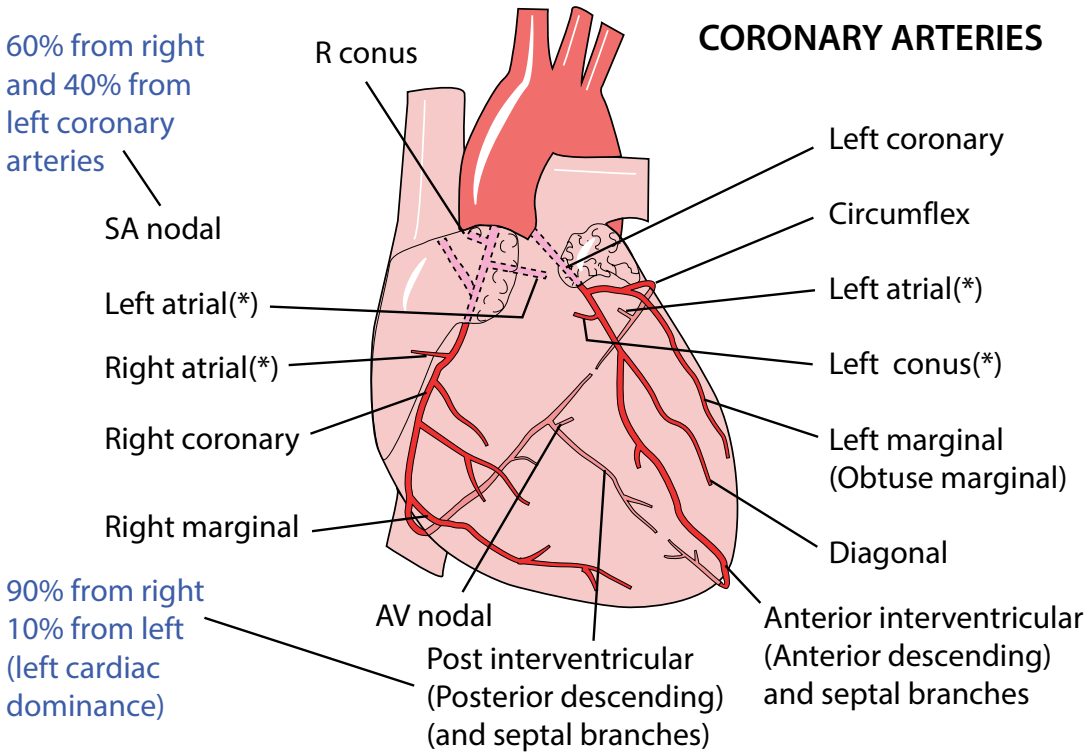
Tendon of Todaro sitting on central fibrous body and AV node just to its left (If central fibrous body calcifies it is then **OS CORDIS**)

A-B hold mitral valve
C-D hold tricuspid valve



The fibrous skeleton is a remnant of atrioventricular cushions. It divides the atria from the ventricles and supports the valves. It separates the atria from ventricles electrically. The membranous interventricular septum is attached to it.

CORONARY ARTERIES

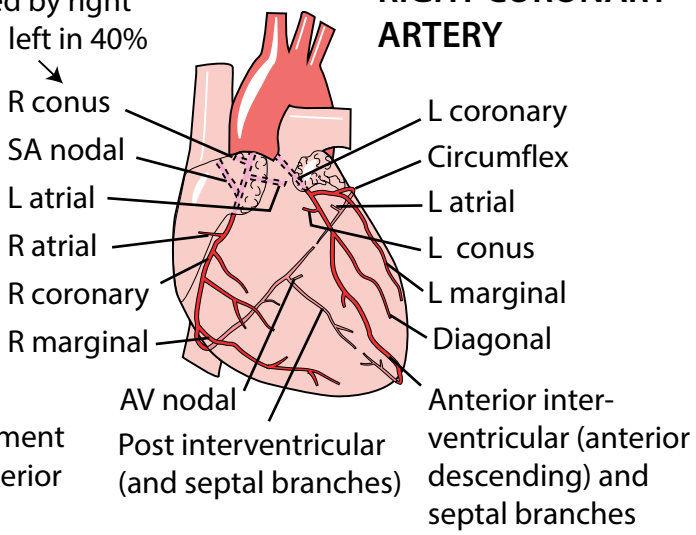


(*) = Not clinically important vessels

RIGHT CORONARY ARTERY

SA node is supplied by right artery in 60% and left in 40%

RIGHT CORONARY ARTERY:
From anterior aortic sinus.
Supplies: SA node in 60% and AV node in 90%. **Branches:** R conus, L atrial, SA node, R atrial, R marginal, AV node, posterior interventricular (in 90%) with septal branches

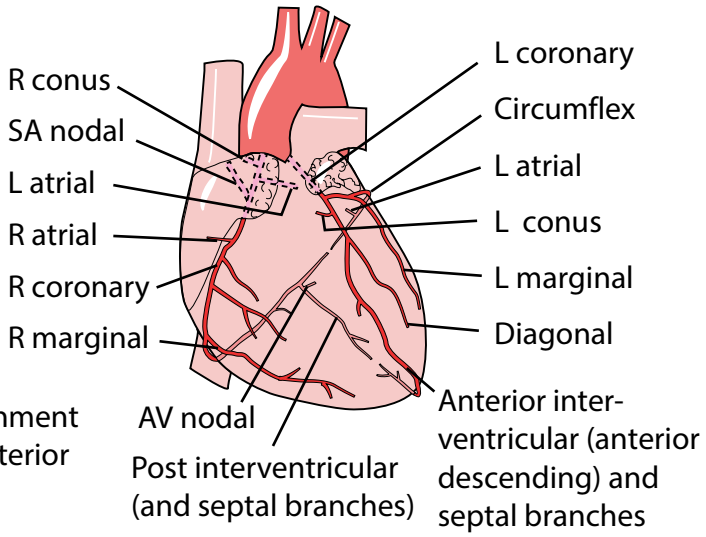


Ostia of these arteries are above attachment of base of relevant cusp. Right from anterior sinus and left from left posterior sinus.

Right artery passes anteriorly between right atrial appendage and pulmonary trunk into right anterior atrioventricular (AV) groove and then right posterior AV groove where it anastomoses with circumflex branch of left coronary artery. In 90% of people it gives the posterior interventricular artery which anastomoses with termination of anterior interventricular artery (left coronary) in this groove. The AV node is supplied by right coronary artery in 90% of people

LEFT CORONARY ARTERY

LEFT CORONARY ARTERY: From left posterior aortic sinus. Supplies: SA node in 40% and AV in 10%. Branches: Circumflex, L atrial, L conus, anterior interventricular, diagonal and posterior ventricular (in 10%) with septal branches.



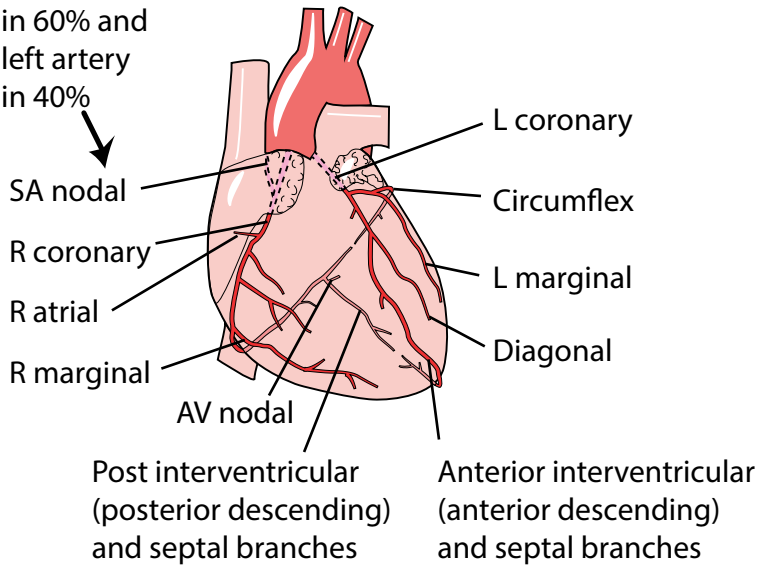
Ostia of these arteries are above attachment of base of relevant cusp. Right from anterior sinus and left from left posterior sinus.

Left artery passes anteriorly between left atrial appendage and pulmonary trunk into left anterior AV groove. It divides into anterior interventricular and circumflex arteries. The latter artery continues first in anterior and then in posterior AV groove. It anastomoses with terminal branches of right coronary artery. In 10% of people it gives posterior interventricular artery (left dominence) and also supplies AV node. Anterior interventricular (anterior descending) passes down and around apex of heart to anastomose with terminal branches of posterior interventricular artery.

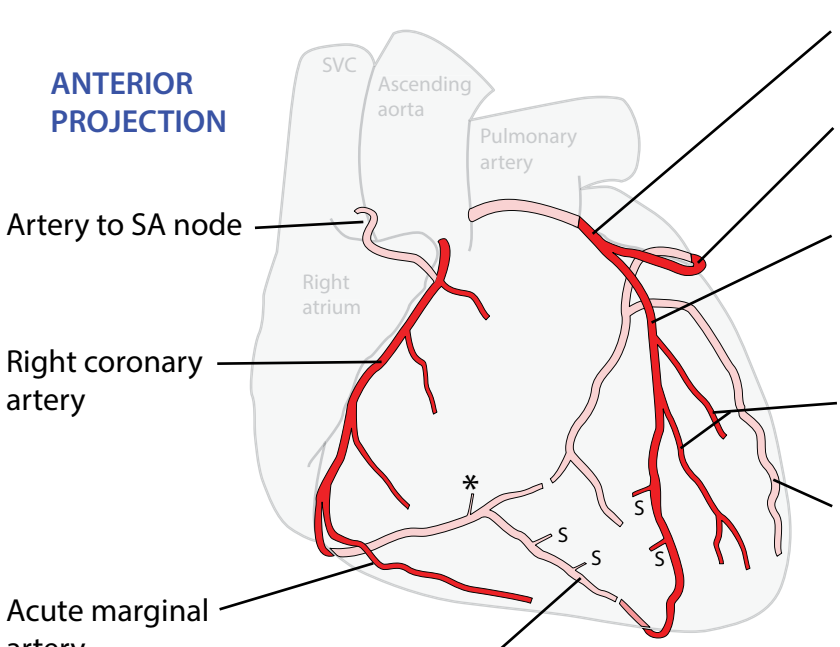
CARDIAC DOMINANCE

DOMINANCE
In 10% of people the left coronary artery gives the posterior interventricular artery. This is **left cardiac dominance** and means that both ventricles and septum are supplied by the single left coronary artery. Left cardiac dominance is associated with the presence of a bicuspid aortic valve

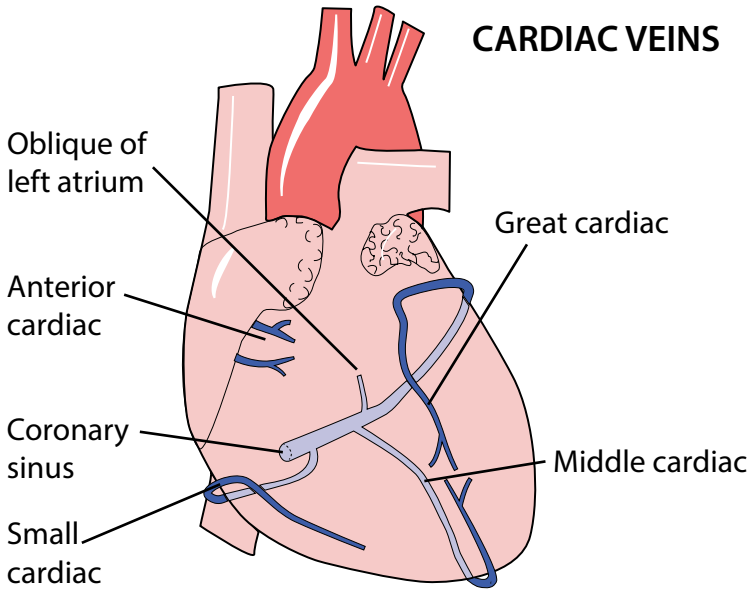
SA node is supplied by right artery in 60% and left artery in 40%



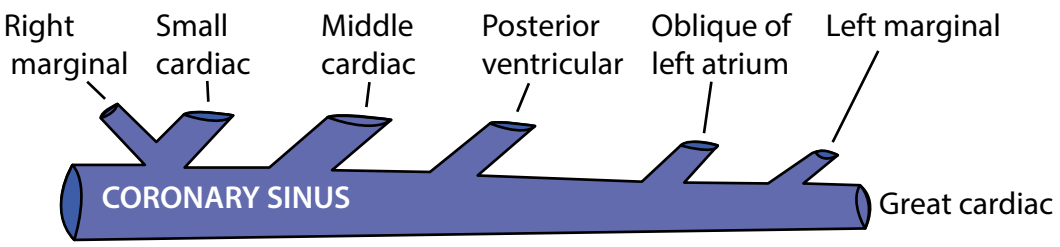
CORONARY ARTERIES AS SEEN ON A CORONARY ANGIOGRAM



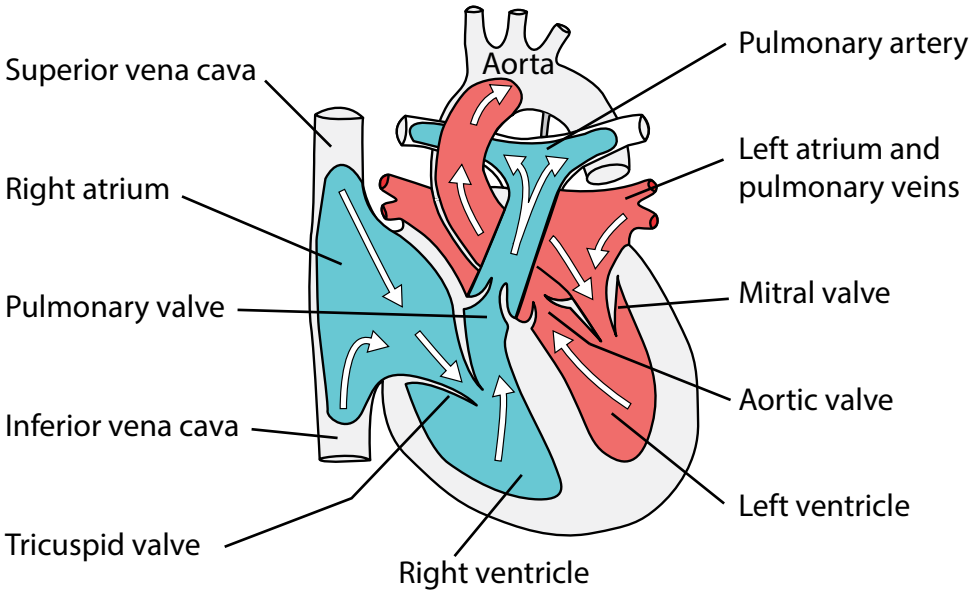
CARDIAC VEINS



- More variable than arteries
- **Coronary sinus** drains into right atrium just to left of opening of the inferior vena cava (IVC)
- **Right marginal vein** drains right ventricle. It ends either in the anterior cardiac veins, the coronary sinus or directly into the right atrium
- **Small cardiac veins** may enter the coronary sinus or directly into the right atrium
- 20-30% of all drainage is via **VENAE CORDIS MINIMAE** (Thebesian veins). They open into all chambers, mostly right sided



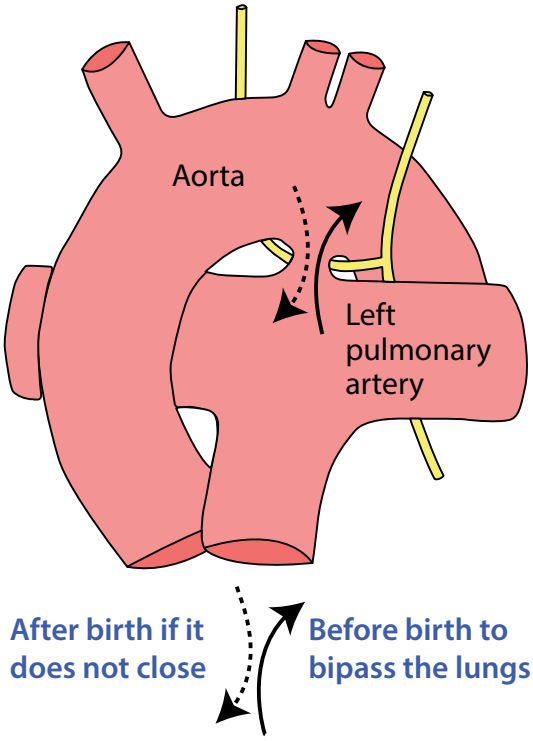
NORMAL CIRCULATION IN THE HEART

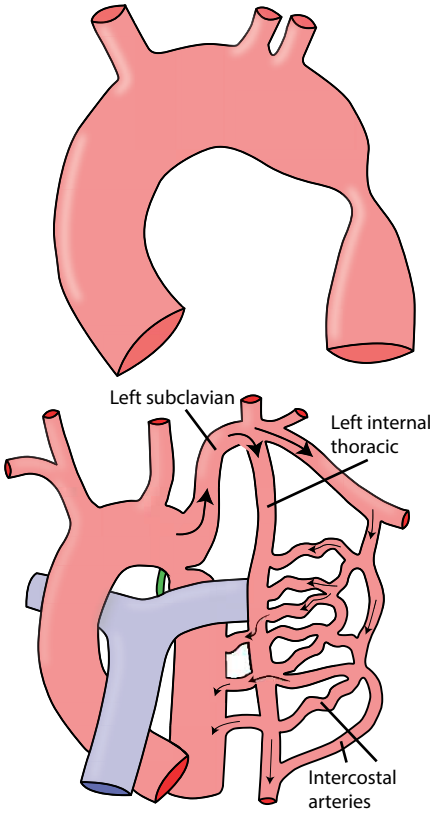


PATENT DUCTUS ARTERIOSUS

Embryologically the ductus arteriosus is the distal part of the left 6th aortic arch.
In fetal life blood shunts from the higher pressure pulmonary artery to the aorta as a means of bypassing the fetal lungs.
After birth it closes due to the lack of **maternal prostaglandins** and the production of **bradykinin** from the fetal lungs to become the ligamentum arteriosum. If it does not close then high pressure aortic blood raises the pressure in the pulmonary circulation.
It may be an isolated finding or part of a complex congenital heart problem.
It can be closed surgically or by giving antiprostaglandins.

Note: During surgical correction, there is a risk of damaging the left recurrent laryngeal nerve



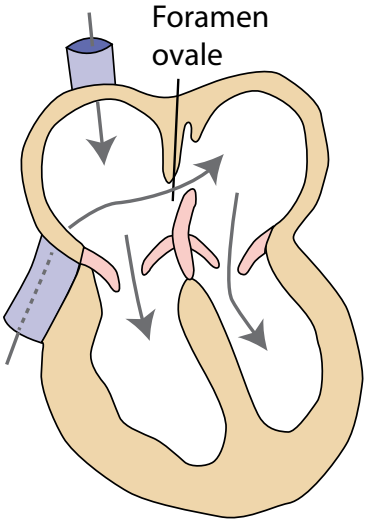


COARCTATION OF AORTA

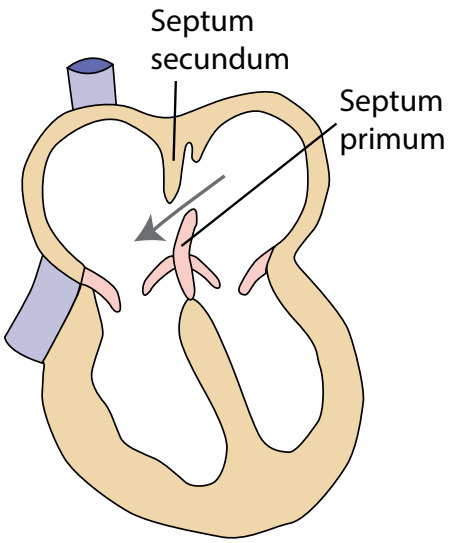
A congenital narrowing of aorta at or near site of ligamentum arteriosum caused by hypoplasia of the 4th arterial arch with post-stenotic dilatation. Maybe due to spread of ductus tissue into the aorta, narrowing it when the ductus arteriosus closes off.

Enlarged collateral circulations in internal thoracic, subclavian and posterior intercostal arteries. Erosion of ribs with "notching".
Poor femoral pulses in both limbs.
Treatment is surgical.

NORMAL FETAL CIRCULATION

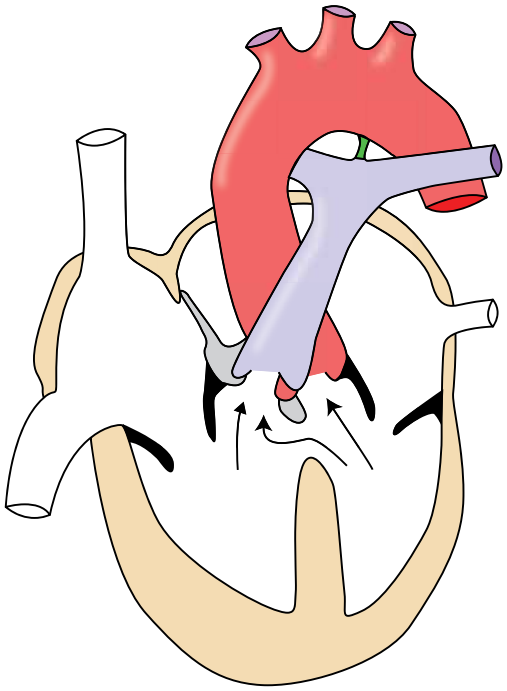


ATRIAL SEPTAL DEFECT



Atrial septal defect: Often associated with a ventricular septal defect. Treatment for septum secundum is a surgical graft. For septum primum it is more difficult surgery. Often associated with VSD.
Note: Blood flows from the higher pressured left atrium to the right atrium and only when there is a temporary rise in right atrial pressure will there be the possibility of cyanosis

INTERVENTRICULAR SEPTAL DEFECT (VSD)



The upper membraneous part, which is formed by the inferior end of the spiral septum, is missing

Note: Risk of Eisenmenger Syndrome where the left to right shunt is reversed due to right ventricular hypertrophy and resulting increasing right sided pressure. This risk is lessened by early corrective surgery

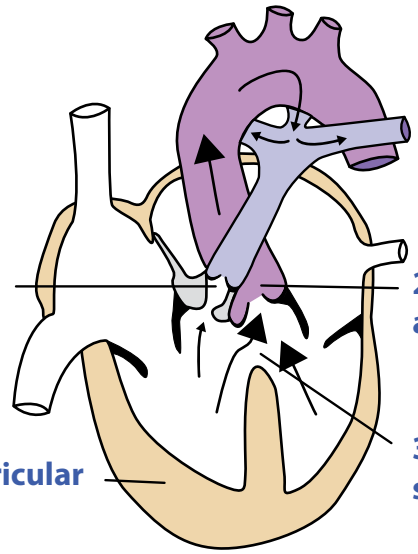
EISENMENGER'S SYNDROME

EISENMENGER'S SYNDROME occurs when there is reversal of a left-to-right shunt to become a right-to-left shunt, such as in a ventricular septal defect or Fallot's tetralogy where there is an increase in flow and pressure in the right heart. There is right ventricle hypertrophy and subsequent rise in pulmonary artery pressure. The shunt occurs when the right sided pressure exceeds the left sided pressure. Cyanosis occurs as the blood becomes desaturated and this leads to dyspnoea.

In the presence of Eisenmenger's Syndrome, it might be unwise to close the shunt as it is acting as a means of decompressing the pulmonary circulation.

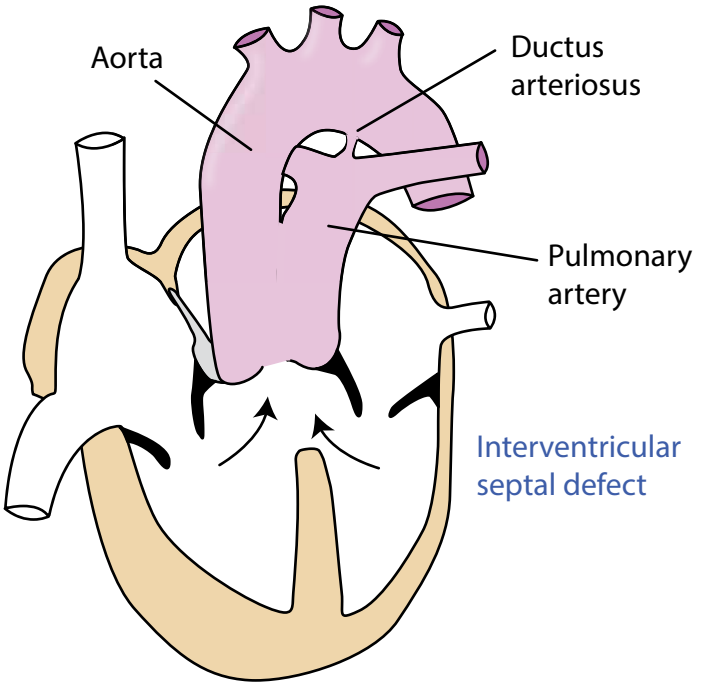
Eisenmenger's syndrome is now less common due to earlier corrective surgery.

FALLOT'S TETRALOGY



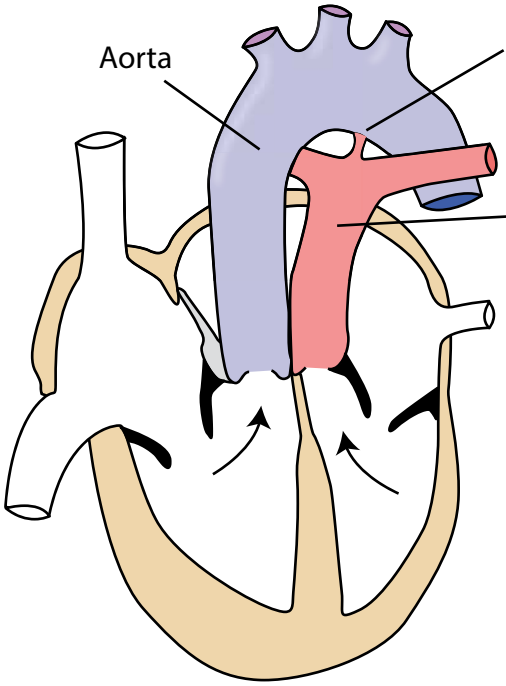
The spiral septum (neural crest cells) divides the truncus arteriosus asymmetrically giving a narrow pulmonary trunk and a wider aorta. Failure of the lowest part of the spiral septum to form the membraneous part of the interventriculum leaves a septal defect. As blood cannot reach the lungs by the pulmonary trunk, the ductus arteriosus needs to be kept open. This is a primarily cyanotic condition that requires major surgery.

PERSISTENT TRUNCUS ARTERIOSUS



The spiral septum has failed to divide the truncus arteriosus partially or completely into two vessels. Blood from both ventricles is pumped into both the pulmonary and systemic circulations. Major surgery is needed.

TRANSPOSITION OF GREAT VESSELS



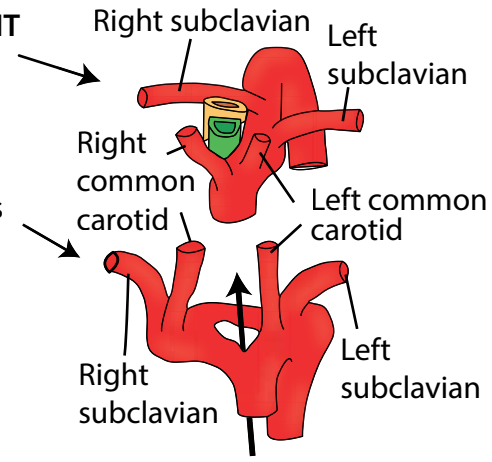
The spiral septum has failed to divide the truncus arteriosus correctly and this results in two totally separate circulations - pulmonary and systemic that are not connected. Major surgery is required but some oxygenation can be achieved by keeping the ductus arteriosus patent.

OTHER CONGENITAL ANOMALIES OF HEART

RETRO-OESOPHAGEAL RIGHT SUBCLAVIAN ARTERY
Gives dysphagia lusoria

DOUBLE AORTIC ARCH
Vascular ring enclosing trachea and oesophagus

See also:
PERSISTENT RIGHT DORSAL AORTA

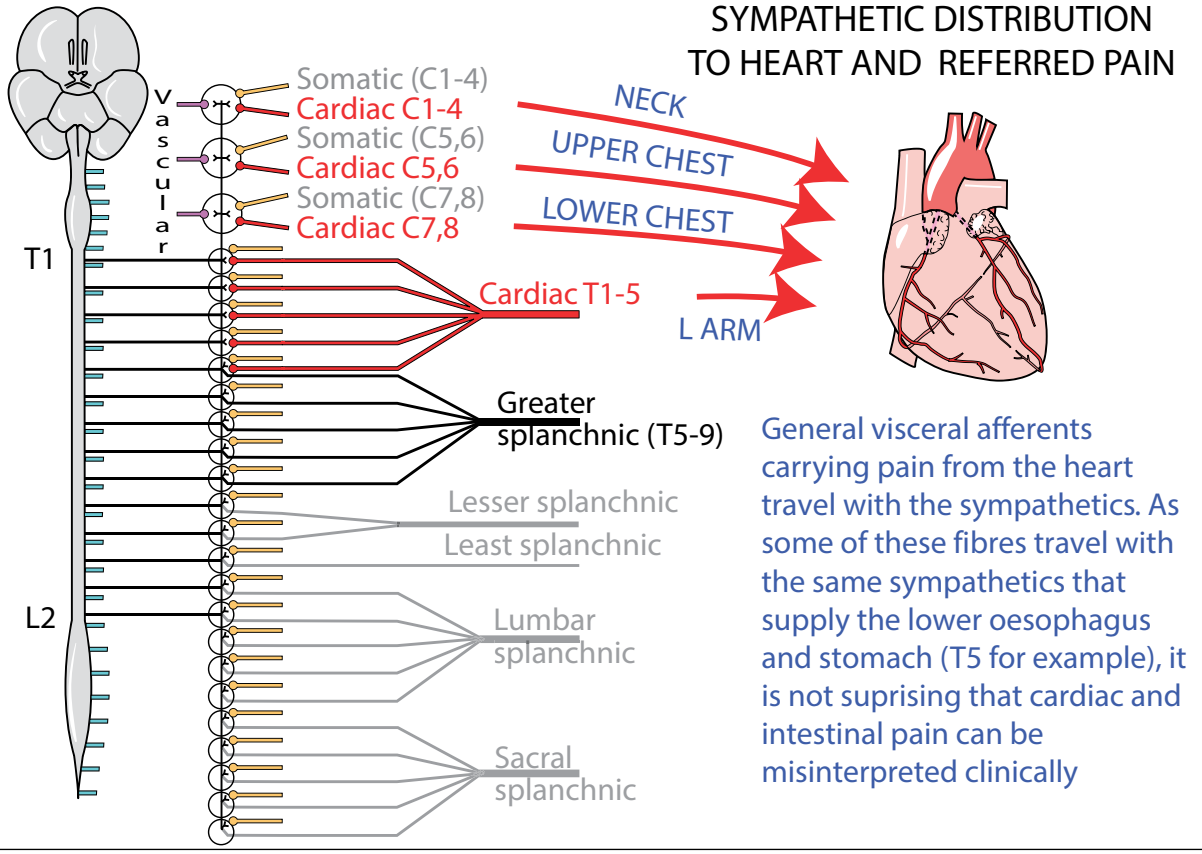


CYANOTIC CONDITIONS

- Persistent truncus with VSD
- Transposition of aorta with patent ductus and VSD
- Fallot's tetralogy
- Pumonary atresia with patent ductus
- Tricuspid atresia with ASD

ACYANOTIC CONDITIONS

- Primary/secondary ASD
- Membranous/muscular VSD
- Patent ductus

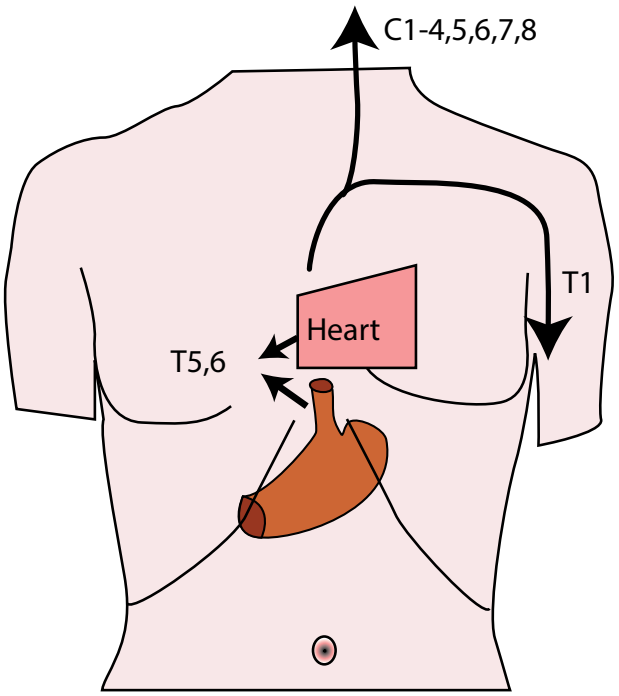


AUTONOMIC REFERRED PAIN

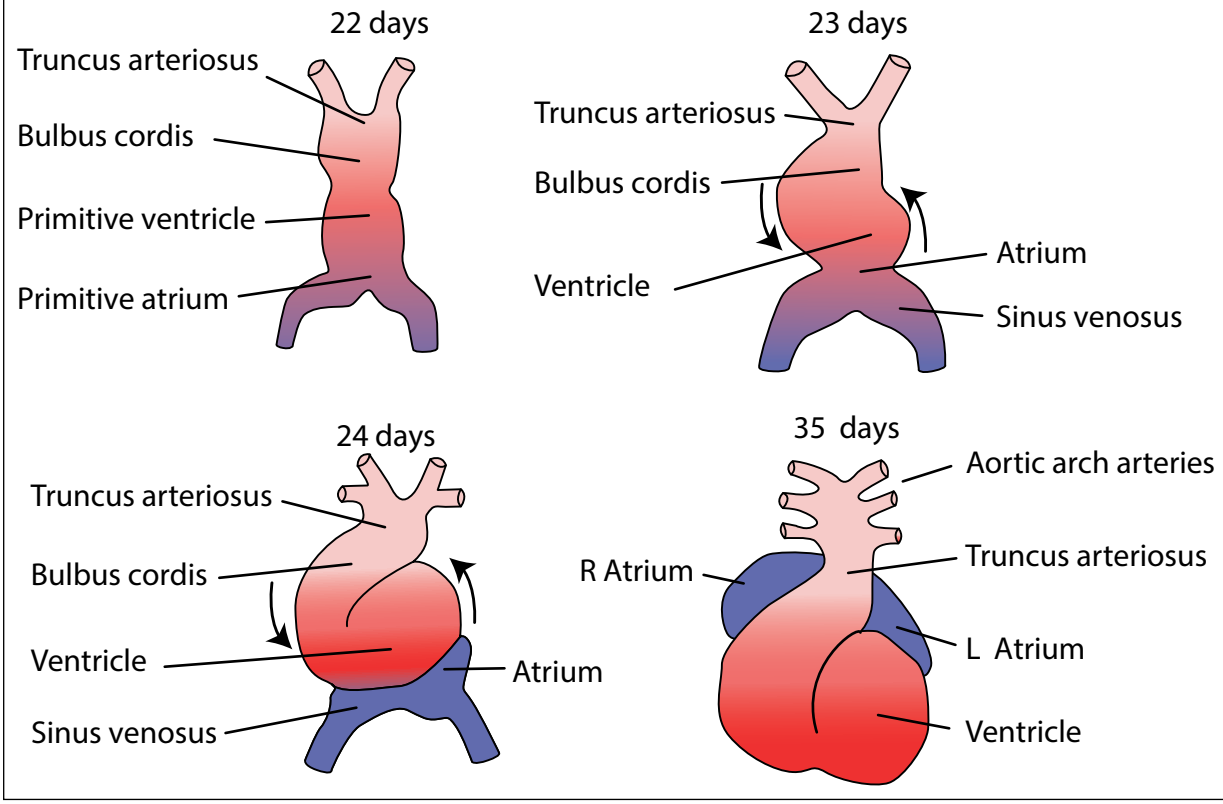
General visceral afferents from the heart (via sympathetics) refer pain to:
Neck
Left arm
Epigastrium

Note that the T5,6 sympathetics not only supply the **heart** but also the lower **oesophagus and stomach** so the body can confuse indigestion with coronary pain.

Note: See also details on referred pain in abdominal section



LOOPING OF HEART



PERCENTAGES OF OXYGEN IN FETAL CIRCULATION

Flow: Blood entering R ventricle is a combination of SVC, coronary sinus, ventral streaming from IVC (lower body and hepatic veins)

Flow: In pulmonary art is 12% of which 88% enters the DA which functionally shuts in minutes after birth and anatomically closed in 3-7 days

Flow: 40% of umbilical blood passes through F. ovale

LUNG

LUNG

O_2: SVC/coronary sinus 25-40%

O_2: Left atrium 65%

Dorsal streaming of 65% O_2 for F. ovale and ventral streaming 25% O_2 for R atrium

IVC

O_2: 5-10% more in arch of aorta than in descending aorta

Ductus venosus

Aorta

Liver

O_2: Left ventricle for coronary arts and brain 65%

Flow: approx 50% of placental blood goes to liver via portal vein. Other 50% to IVC

Flow from ventricles: 55% of fetal cardiac output goes through umbilical arteries to the placenta. 8% to pulmonary circulation

O_2: Umbilical vein 80-90%

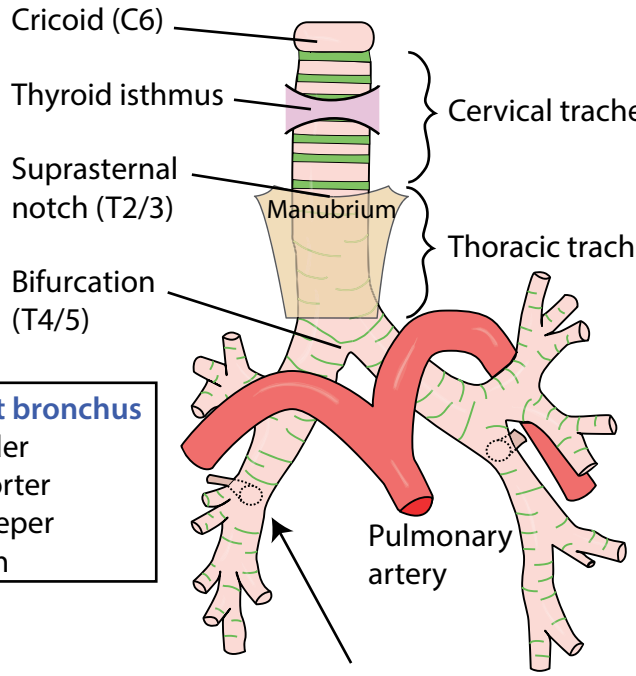
O_2: Maternal blood 98%

O_2: IVC before ductus venosus 25%

Placenta

3.4 Trachea, Lungs and Oesophagus

RELATIONS OF TRACHEA & BRONCHI



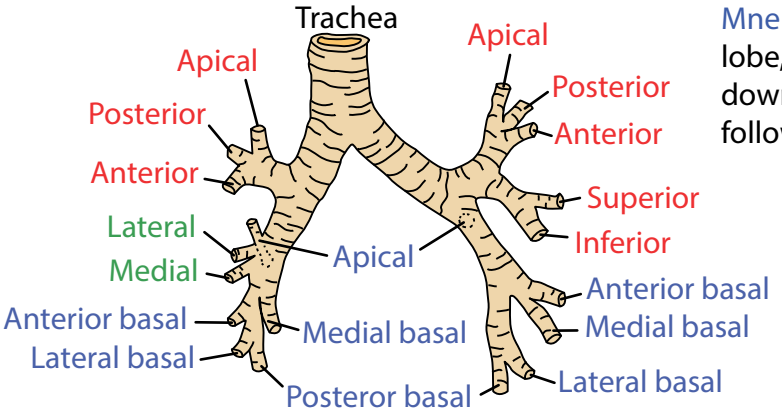
Elastic structure so in inspiration it can elongate to 15cm. Mucosa ciliated, pseudostratified columnar. Hyaline cartilage rings

Right bronchus
Wider
Shorter
Steeper
2cm

Left bronchus
Narrower
Longer
More horizontal
5cm

Inhaled foreign bodies are more likely to enter the right main bronchus and then pass into the apical bronchus of the right lower lobe - the first one that points posteriorly

BRONCHOPULMONARY SEGMENTS



Mnemonic: Starting on right at upper lobe, working down right lobe then down left lobe the segments are as follows: APALM APALM APAIS APAL

Red = Upper lobe **Blue** = Lower lobe **Green** = Middle lobe

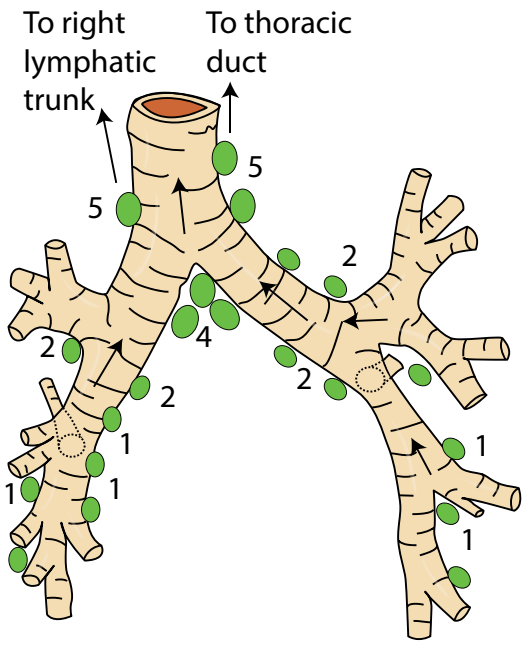
BRONCHI
Blood supply: Bronchial arteries from aorta. (2 on left, 1 on right)
Venous drainage: Right: azygos. Left: hemiazygos. Also a little via bronchial veins and pulmonary veins
Nerve Supply: Pulmonary plexus at hilum

PARASYMPATHETIC (vagus)
Vasodilatation
Bronchoconstriction
Increase glandular secretions
Sensation

SYMPATHETIC (chain)
Vasoconstriction
Bronchodilatation (beta 2)
Suppress glandular secretion (alpha)

Lymph: Hila nodes then carina then tracheobronchial then thoracic duct and right lymphatic duct

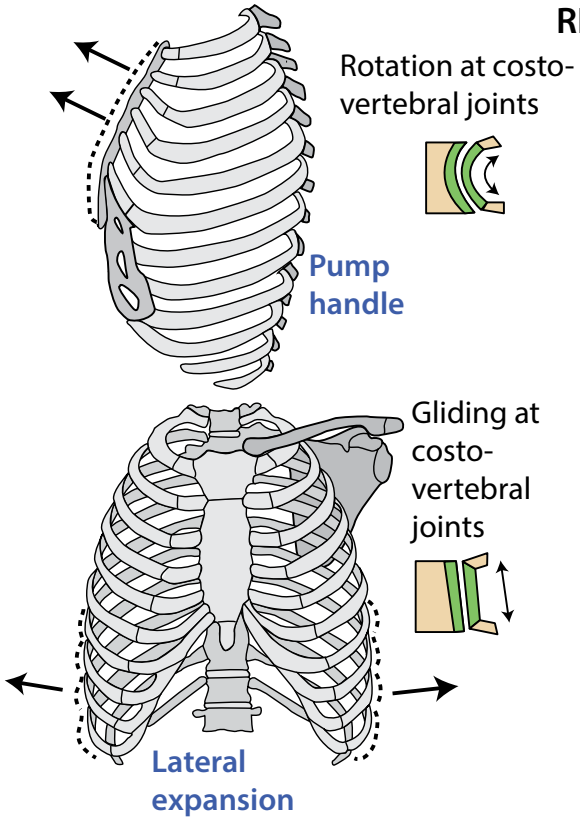
LYMPHATIC DRAINAGE OF LUNGS AND BRONCHI



NODES

1. Intrapulmonary
2. Bronchopulmonary (hilar)
3. Superior tracheobronchial
4. Inferior tracheobronchial (carinal)
5. Paratracheal

RIB MOVEMENTS IN RESPIRATION



Upper thorax (ribs 1-6)

There is **pump handle** movement on inspiration. Mostly anteroposterior expansion - minimal lateral expansion

Lower thorax (ribs 7-10)

In quiet inspiration the costal margins separate producing lateral and slight upwards movement of the whole lower thorax.

In forced inspiration there is an additional eversion of the last few ribs by the diaphragm pulling on them. This is likened to the lifting of a **bucket handle** (not illustrated)

MUSCLE ACTION IN RESPIRATION

3 INTERCOSTAL MUSCLES

Lift ribs and increase in activity the deeper the inspiration. Minimal activity in quiet respiration

DIAPHRAGM (C3,4,5)

70% of quiet inspiration (5cm downwards movement of domes). 10cm movement in deeper inspirations

ACCESSORY MUSCLES OF RESPIRATION

(some need fixation of arms to work effectively)

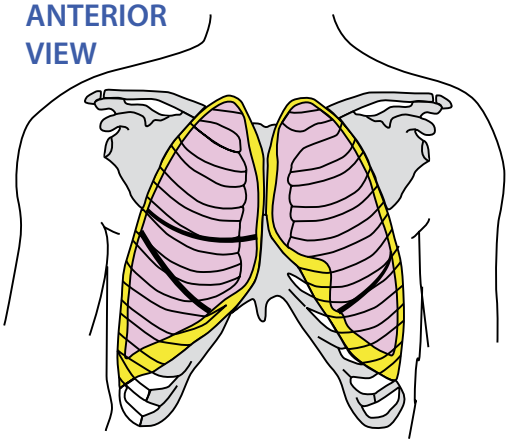
Abdominal wall muscles, 3 scalene muscles, pectoralis major and minor, trapezius, sternocleidomastoid, serratus anterior, latissimus dorsi, erector spinae, quadratus lumborum

MUSCLES ATTACHED TO COSTAL CARTILAGES

- Internal oblique abdominis
- Transversus abdominis
- Rectus abdominis
- Transversus thoracis (sternocostalis)
- Pectoralis major (1-7)
- Diaphragm

PLEURAL AND LUNG SURFACE MARKINGS

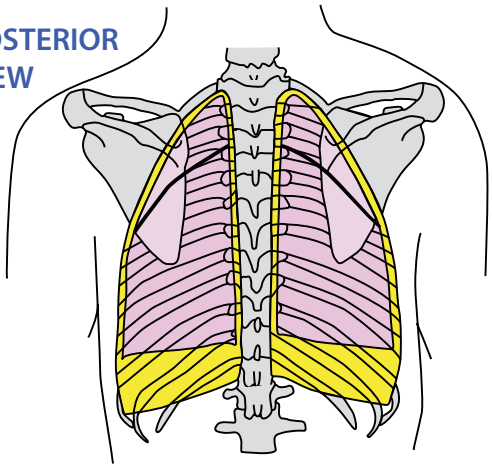
ANTERIOR VIEW



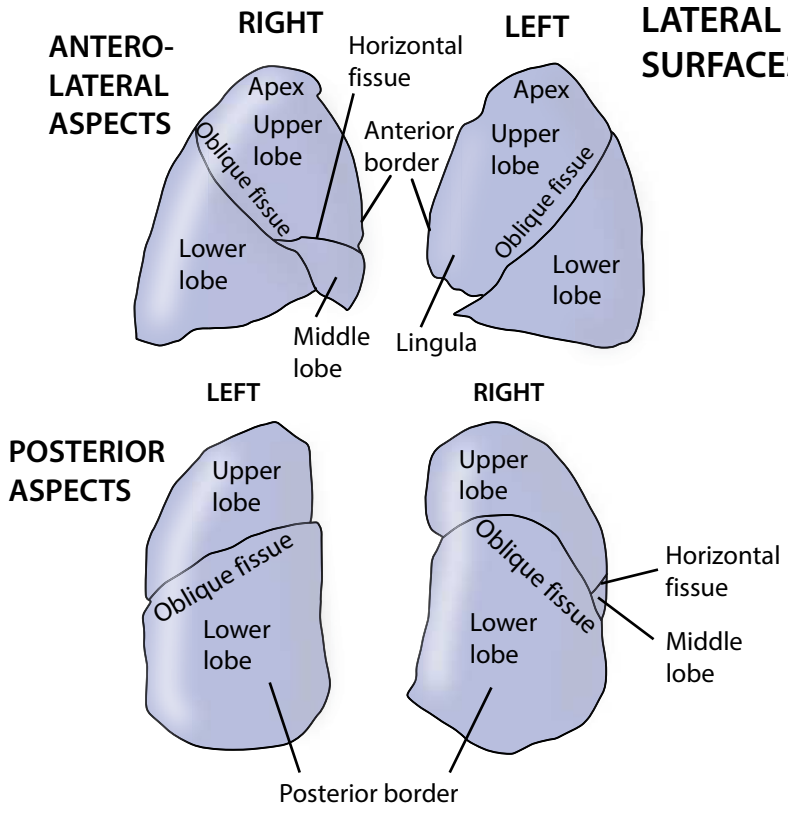
Lung is purple
Pleura is yellow

Note that the pleura extends just below the 12th rib posteriorly. This is important in approaching the kidney surgically from behind

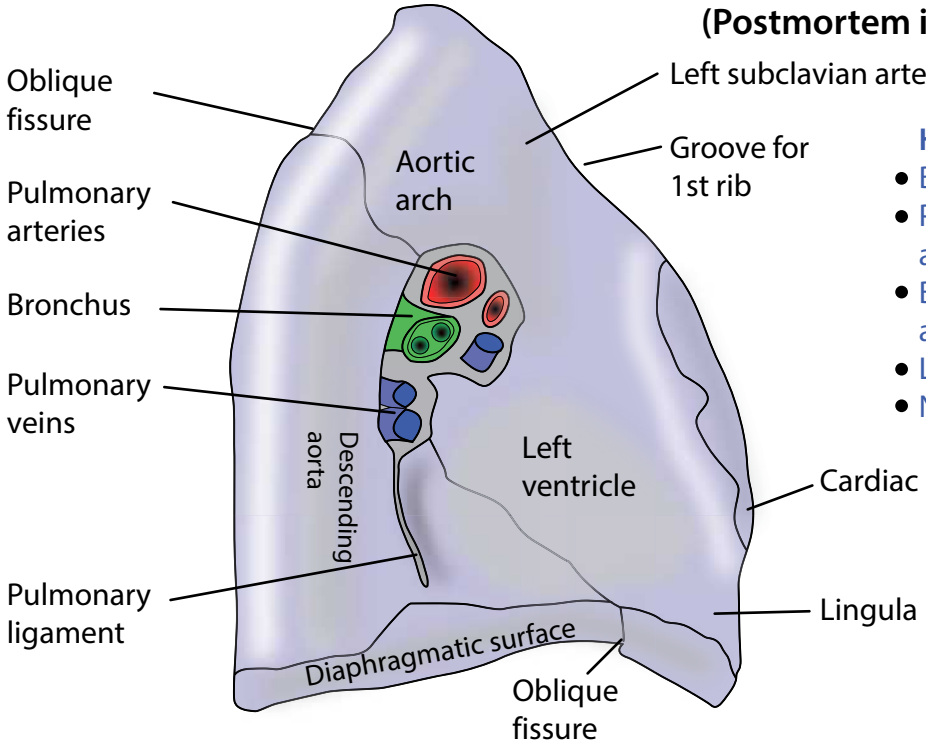
POSTERIOR VIEW



LATERAL AND POSTERIOR SURFACES OF LUNGS



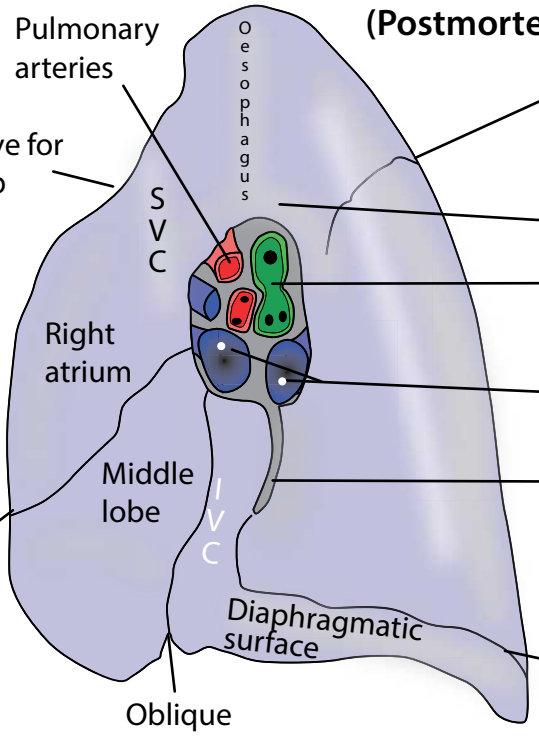
MEDIAL SURFACE OF LEFT LUNG (Postmortem impressions)



Hilum:

- Bronchi
- Pulmonary arteries and veins
- Bronchial arteries and veins
- Lymphatics
- Nerves

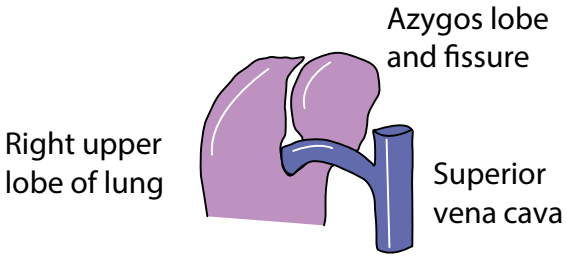
MEDIAL SURFACE OF RIGHT LUNG (Postmortem impressions)



Hilum:

- Bronchi
- Pulmonary arteries and veins
- Bronchial arteries and veins
- Lymphatics
- Nerves

AZYGOS LOBE OF RIGHT LUNG



Occasionally the azygos vein reaches the superior vena cava by passing through the substance of the right lobe trapping a segment of upper right lobe and creating an azygos fissure

Other notes:

- The lingula of the left lobe arises from the upper bronchus
- Incomplete segmentation is common
- Left lung is longer and lower but lighter

DESCENDING AORTA

ANTERIOR VIEW

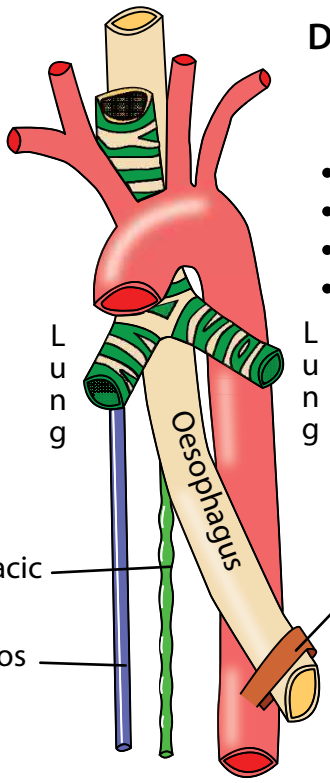
Runs from T4 to T12

To its right

- Right lung
- Left atrium
- Right crus
- Azygos vein
- Thoracic duct

It supplies

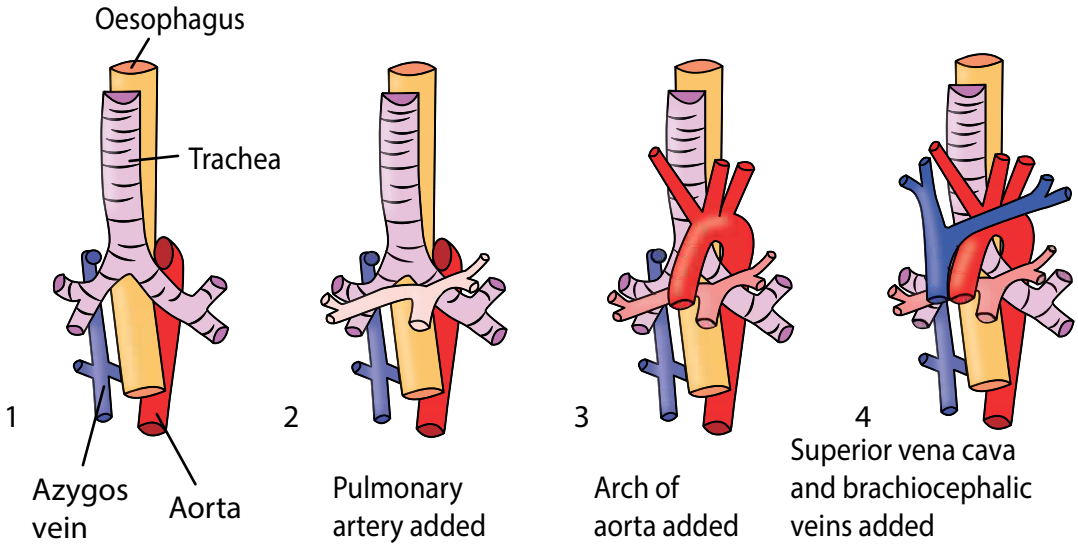
- Posterior intercostals 3-11
- Subcostal (12)
- Oesophageal
- Bronchial
- Phrenic
- Mediastinal
- Spinal



Anterior:

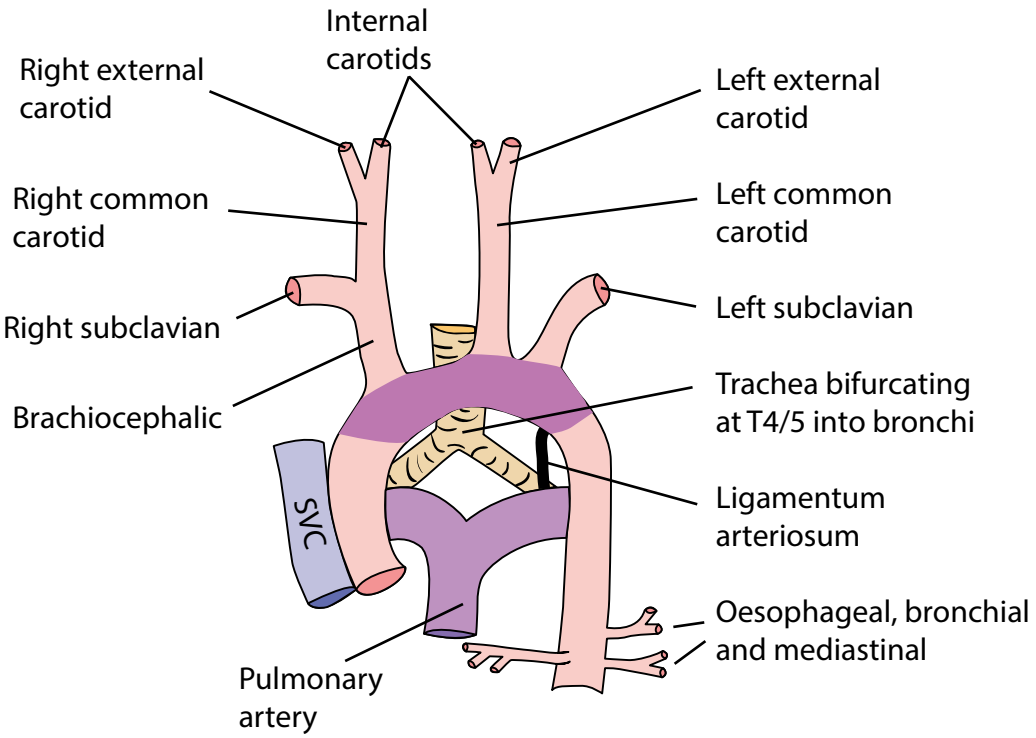
- Crura (mostly right)
- Oesophagus
- Root of left lung
- Left main bronchus

RELATIONS IN THE MEDIASTINUM

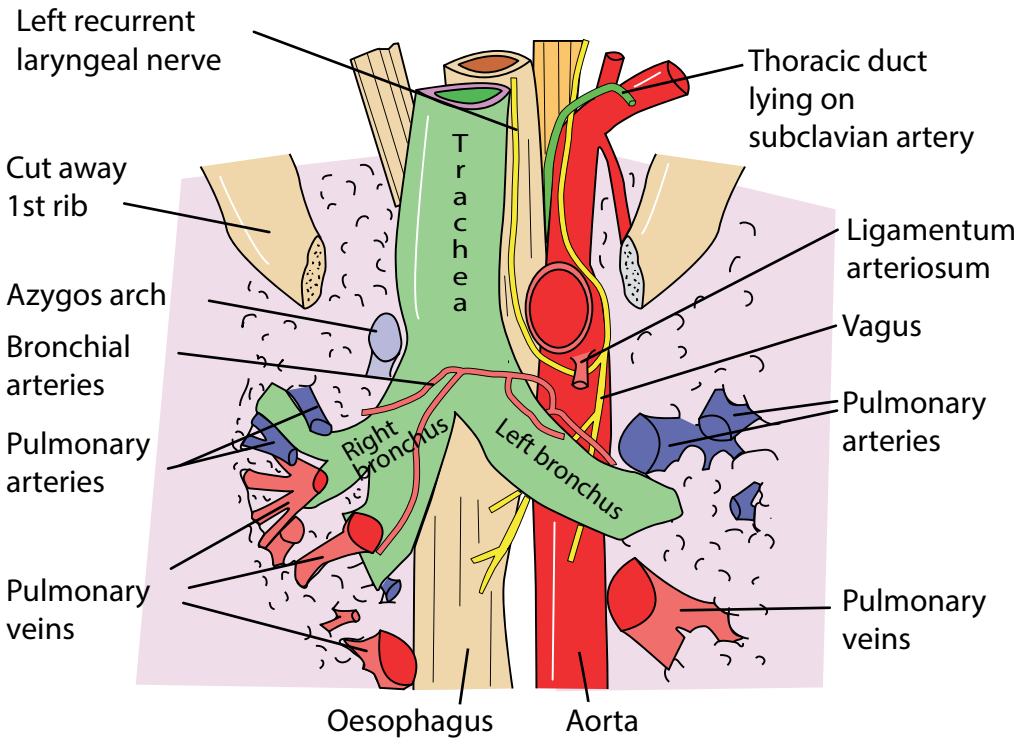


Structures in the mediastinum being built up from posterior to anterior (1-4)

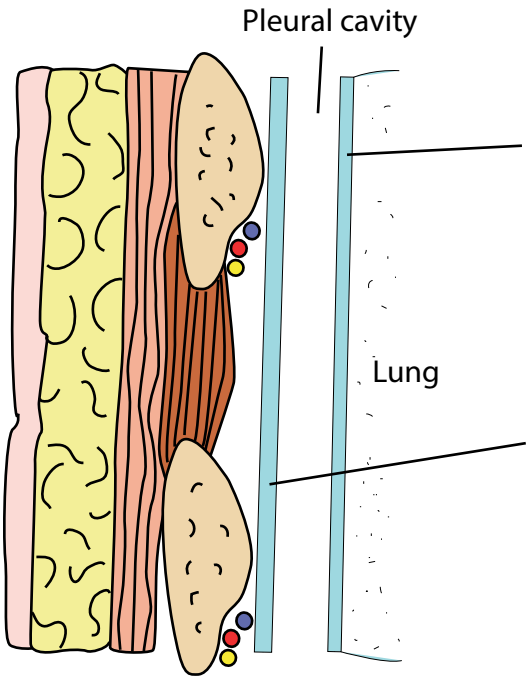
AORTIC ARCH AND ARTERIAL BRANCHES



SUPERIOR MEDIASTINAL RELATIONS



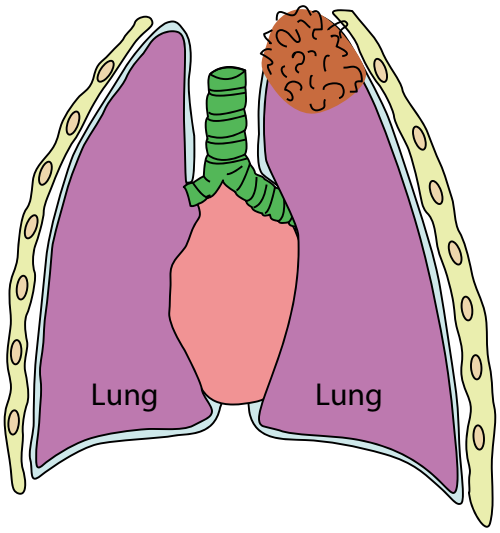
PLEURAL NERVE SUPPLY

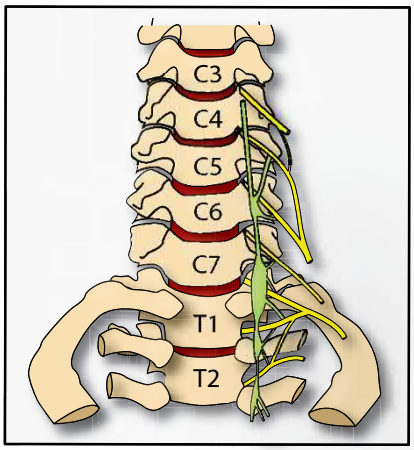


Visceral pleura
Sensory: No somatic but probably general visceral afferent in parasympathetics (vagus) or sympathetics

Parietal pleura
Somatic Sensory:
Phrenic nerve and intercostal nerves

APICAL TUMOUR OF THE LEFT LUNG (PANCOAST'S TUMOUR)

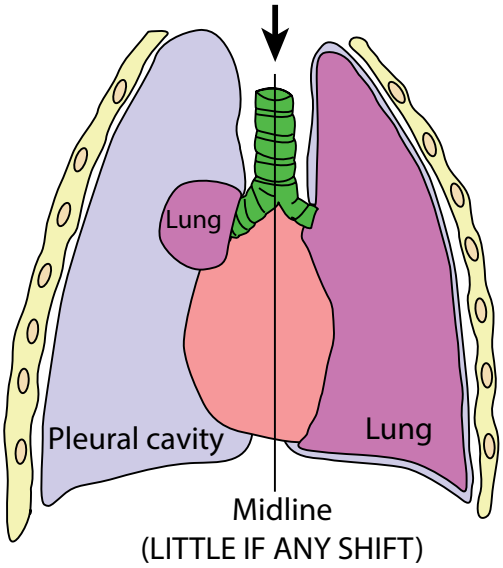




The tumour has invaded the local tissues including the stellate ganglion by the neck of the first rib and hence the sympathetic fibres passing up the chain to the head region. This will result in Horner's Syndrome

The heart and great vessels are not shown in any detail

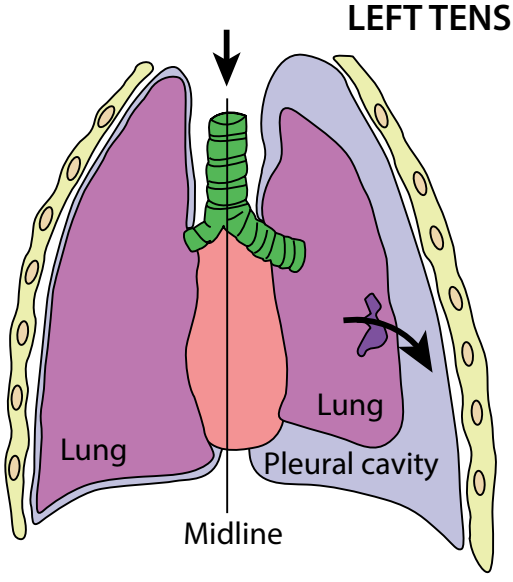
RIGHT SIMPLE NON- TENSION PNEUMOTHORAX



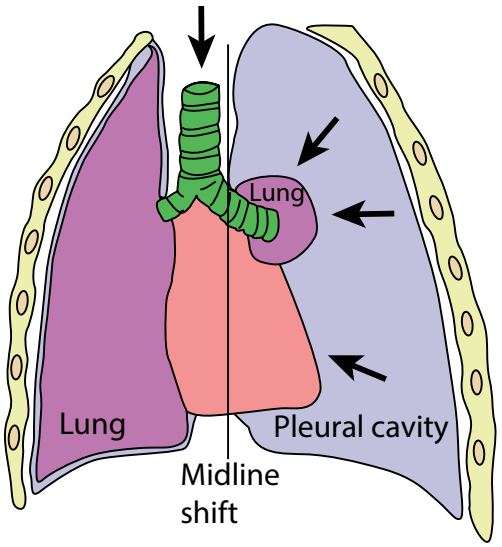
Air has entered the pleural cavity by a defect in the lung (e.g. ruptured bulla) or trauma and the right lung has completely collapsed. The mediastinum has not shifted to the left but there is disappearance of lung markings on the right on an X-ray

The heart and great vessels are not shown in detail

LEFT TENSION PNEUMOTHORAX



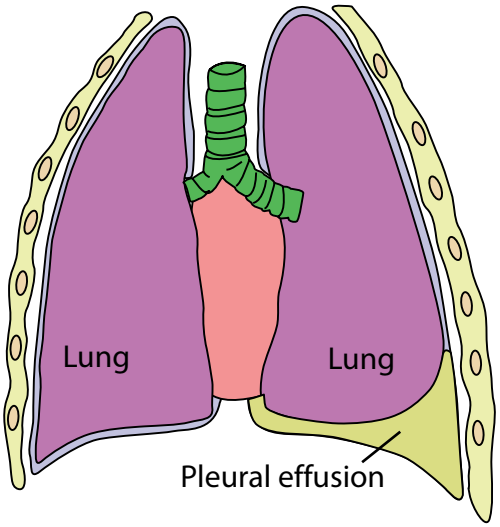
A valvular leak into the pleural cavity from the lung due to tearing of the lung



Left lung completely collapsed, mediastinum shifted to right and disappearance of lung markings on left on X-ray

The heart and great vessels are not shown in detail

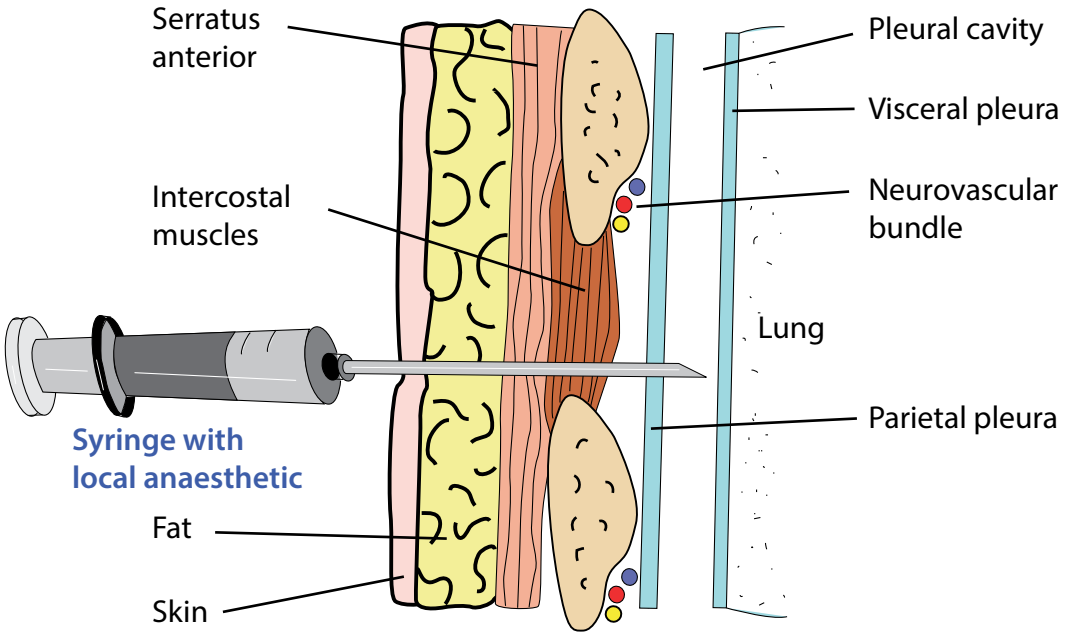
LEFT PLEURAL EFFUSION



Fluid has entered the pleural cavity on the left side and accumulated inferior to the lung.

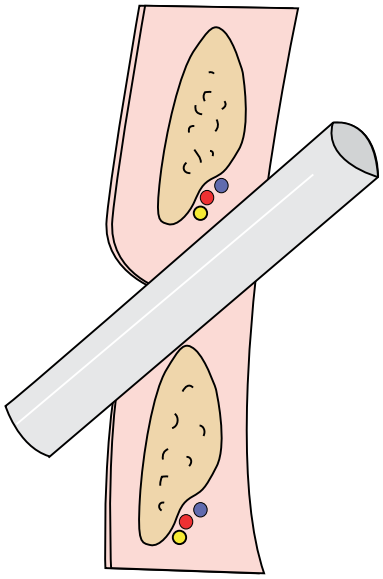
The heart and great vessels are not shown in detail

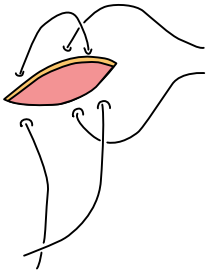
ANAESTHETISING CHEST WALL TISSUES FOR INSERTION OF CHEST DRAIN



INTERCOSTAL DRAIN INSERTION

Aim upwards for air and downwards for fluid. 4th or 5th space in anterior axillary line (to avoid long thoracic nerve), posterior to pectoralis major. Oblique tract to avoid leakage on removal.





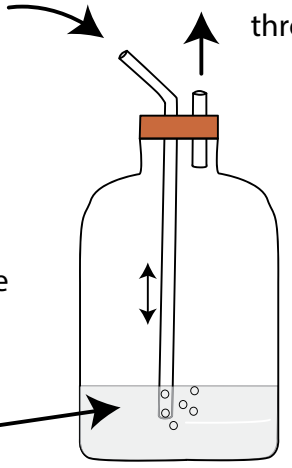
Suture in place and ready to be tied rapidly to avoid air entering the chest when drain is removed

DRAINING A PLEURAL EFFUSION

Chest drain draining air or fluids from the pleural cavity is connected to an underwater seal

Air is forced down this tube (chest drain) during expiration

Air is allowed to escape through this tube



The end of this tube is below the surface of the fluid in the bottle to prevent air returning in the chest tube during inspiration

OESOPHAGUS (27cm long)
C6 - T10

Nerves: Sensation and motor via vagus nerves
Lining: Stratified squamous (non-keratinising) becoming columnar at stomach
Thick muscularis mucosae ++
Mucous glands in mucosa and submucosa

1/3rds	MUSCLE	ARTERY	VEIN	LYMPH	LENGTH (27cm)
Upper	**Striated**	Inferior thyroid	Inferior thyroid	**Deep cervical**	9cm
Middle	**Striated/ smooth**	Aortic branches	Azygos branches	**Mediastinal**	9cm
Lower	**Smooth**	Left gastric	Left gastric	**Gastric**	9cm

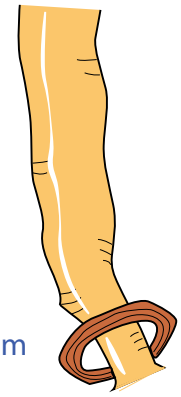
RELATIONS OF OESOPHAGUS

Slight compression (endoscopic narrowings) distance from teeth) from:

Cricoid cartilage 15cm

Aorta 27cm
Left bronchus
left atrium

Diaphragmatic hiatus 40cm



Posterior: vertebrae, thoracic duct crosses to left at T5, hemiazygos/ accessory hemiazygos cross to right at T8/9, descending aorta, first 2 intercostal arteries from aorta

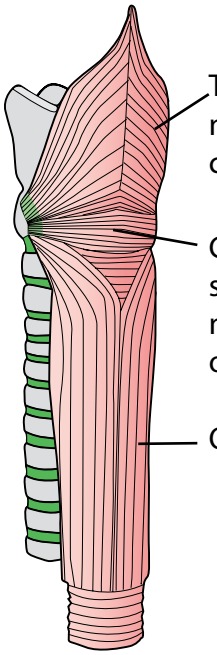
Anterior: trachea to T4/5, recurrent laryngeal nerves, left bronchus, left atrium, diaphragm

Left: thoracic duct, aorta, left subclavian artery, lung

Right: lung, azygos vein (hence good side to approach the oesophagus surgically)

Note: 40-45cm is also the length of thoracic duct, vas, femur, spinal cord and transverse colon

THE ROLE OF CRICOPHARYNGEUS IN THE MALLORY WEISS AND BOERHAAVE'S SYNDROMES



Thyropharyngeus is normally open and closes over a bolus

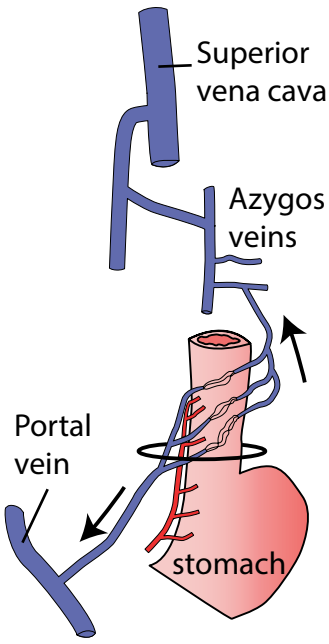
Cricopharyngeus is a sphincter that is normally closed but opens for a bolus

Inferior constrictor

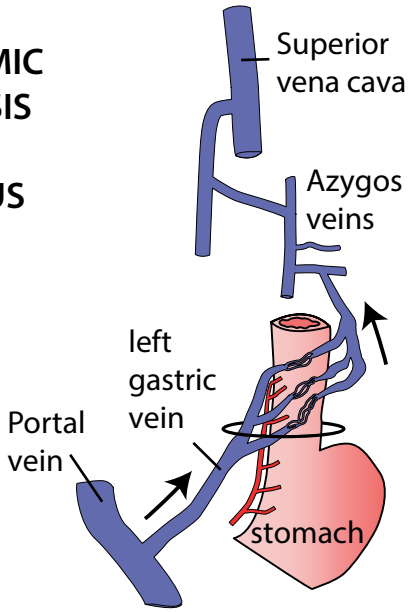
Oesophagus

If it fails to open during a vomit, there is a risk of high pressure within the oesophagus with subsequent tearing of the mucosa or whole wall

PORTOSYSTEMIC ANASTOMOSIS IN LOWER OESOPHAGUS



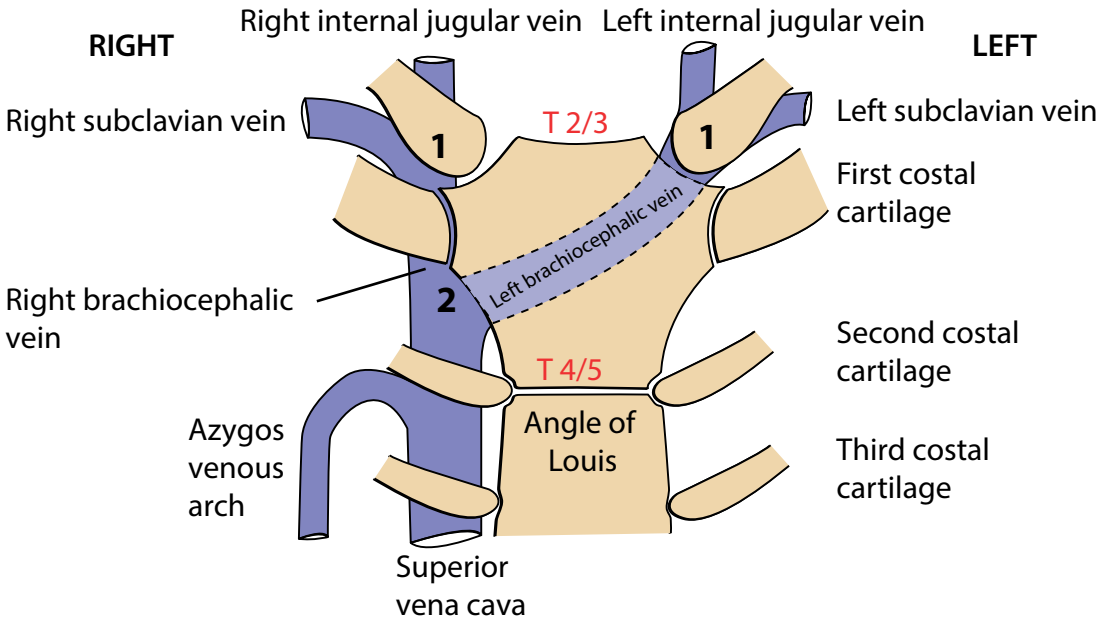
Normally blood drains equally to the portal and systemic systems



In portal hypertension the portal vein is dilated and the pressure is higher than in the systemic circulation. Venous blood flows via the left gastric veins toward the azygos veins and dilates the venous anastomoses in the lower oesophagus giving varicosities that bleed easily

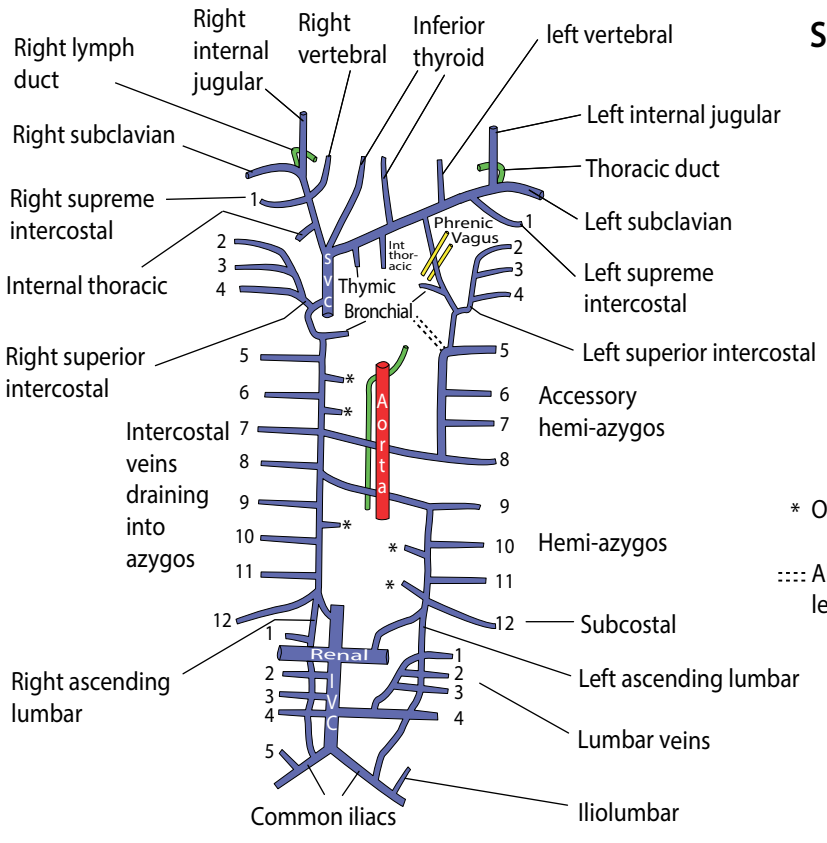
3.5 Vessels and Nerves

VEINS IN UPPER MEDIASTINUM AND LOWER NECK



1 **Formation of brachiocephalic veins posterior to the sternoclavicular joints.**
2 **Formation of the superior vena cava in the first right intercostal space, just inferior to the first costal cartilage.**

SUPERIOR VENA CAVA AND AZYGOS SYSTEMS

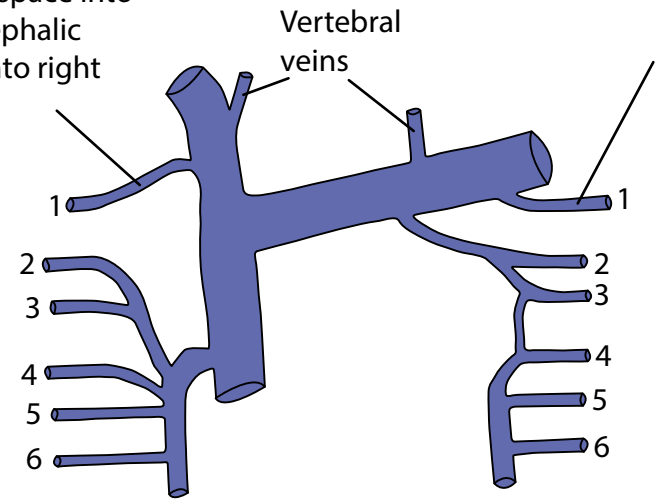


VENOUS DRAINAGE OF INTERCOSTAL SPACES

Right supreme intercostal vein drains 1st space into right brachiocephalic (occasionally into right vertebral)

2,3 spaces into azygos arch via right superior intercostal vein

4,5,6 and all spaces below this into azygos on right

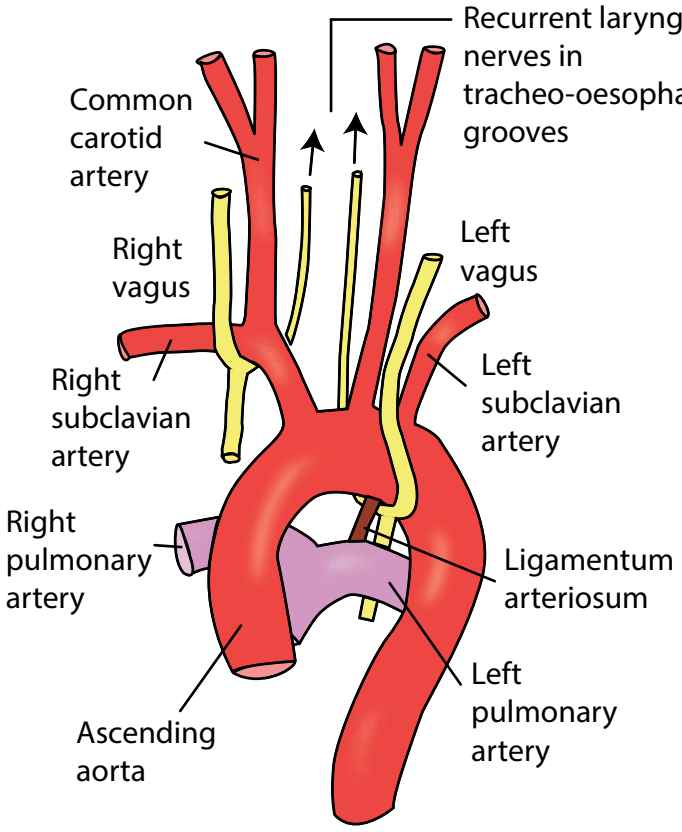


Left supreme intercostal vein drains 1st space to left brachiocephalic

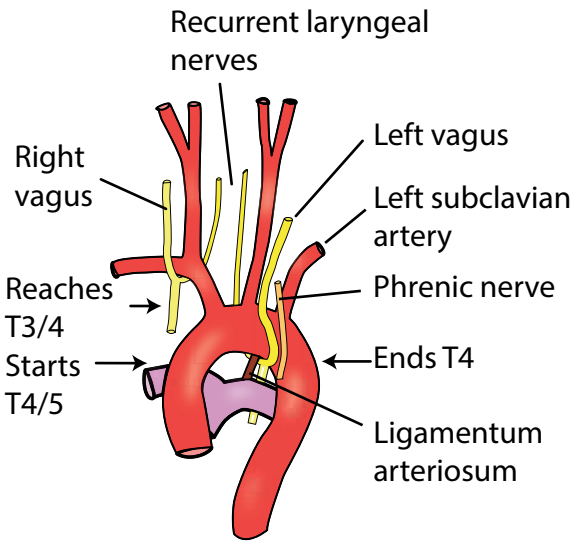
2,3 spaces to left superior intercostal vein to left brachiocephalic

4,5,6 and all spaces below this into hemi-azygos and accessory hemi-azygos on left

MAJOR VESSELS AND RECURRENT LARYNGEAL NERVES



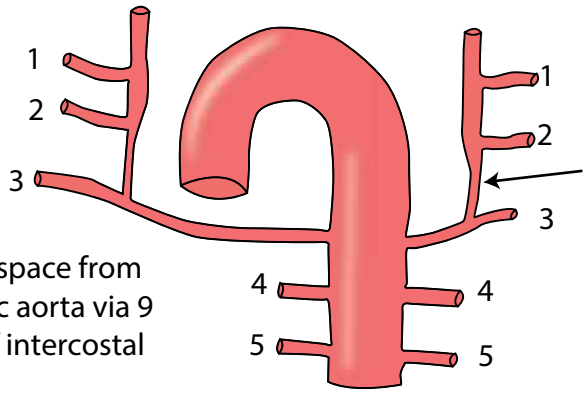
AORTIC ARCH



Relations:
Left: Pleura, vagus, left phrenic nerve
Right: Trachea, oesophagus, thoracic duct, left recurrent laryngeal nerve, superior vena cava, right phrenic nerve
Anterior: Thymus, superficial cardiac plexus, (Inferior cardiac branch of left vagus and left cardiac sympathetic branch from superior cervical ganglion)
Inferior: Ligamentum arteriosum, left recurrent laryngeal nerve, bifurcation of pulmonary trunk, deep cardiac plexus (superior cardiac branch of left vagus, superior and inferior cardiac branches from right vagus, left and right recurrent laryngeal nerves, left cardiac sympathetic branch from middle and inferior cervical ganglion, right cardiac sympathetic branch from all 3 cervical ganglia)

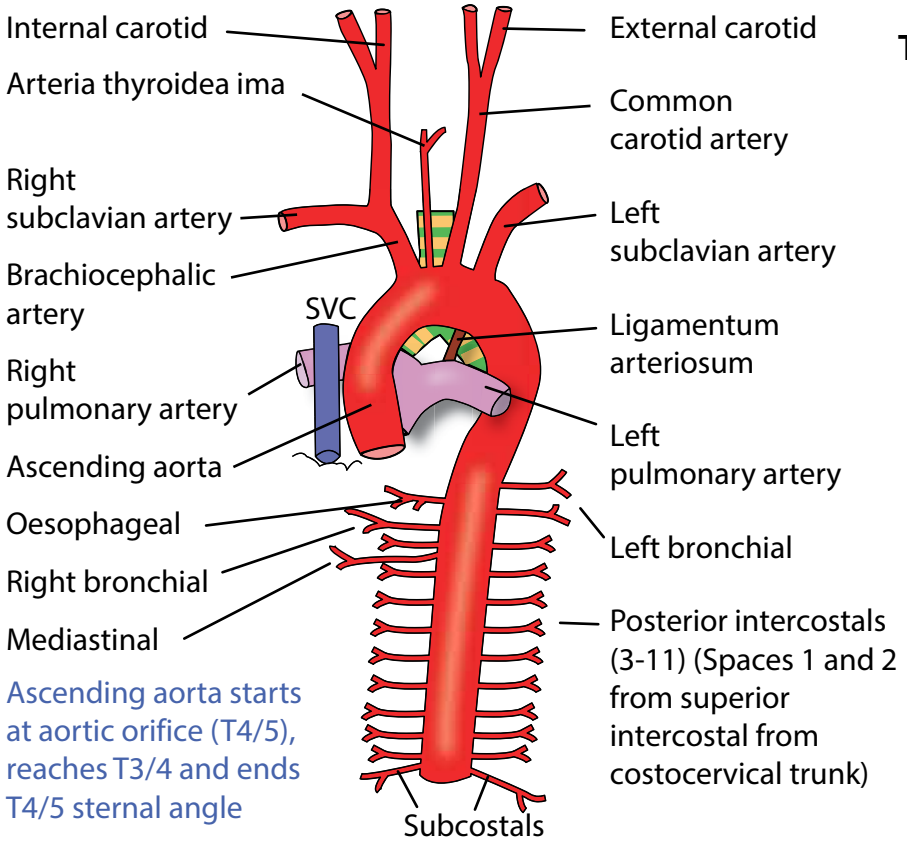
ARTERIAL SUPPLY OF INTERCOSTAL SPACES

SUPERIOR INTERCOSTAL ARTERY (2nd part of subclavian via costocervical artery)
Upper 2 spaces



3-11th space from thoracic aorta via 9 pairs of intercostal arteries

If superior intercostal artery is missing (usually on left) the first 2 spaces are supplied by branches from the aorta

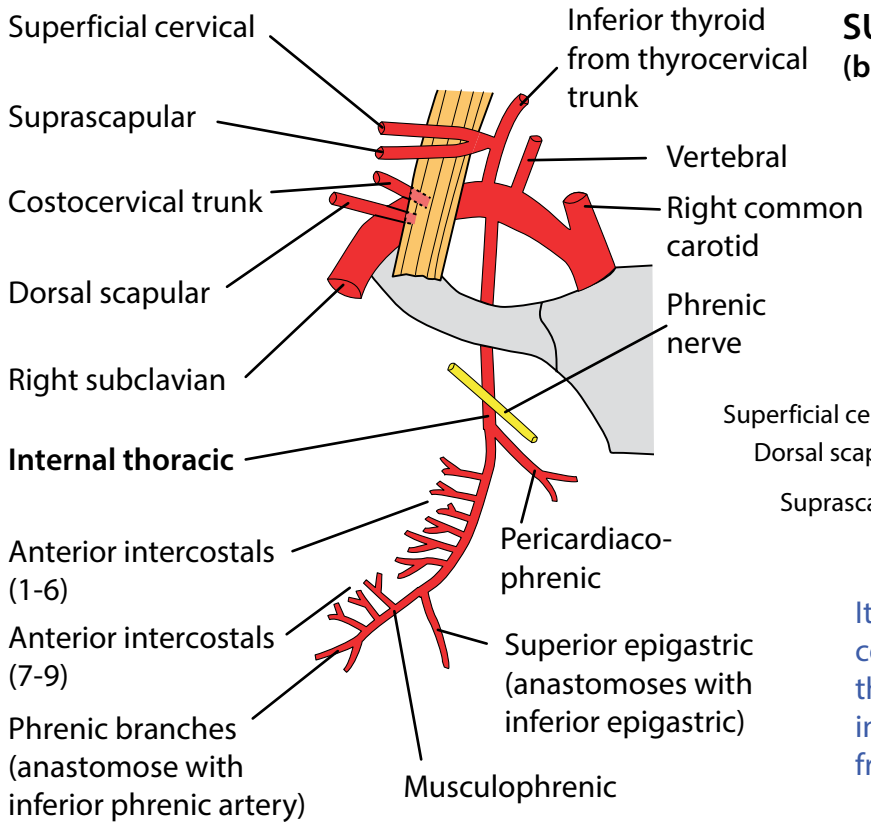


Ascending aorta starts at aortic orifice (T4/5), reaches T3/4 and ends T4/5 sternal angle

THORACIC AORTA

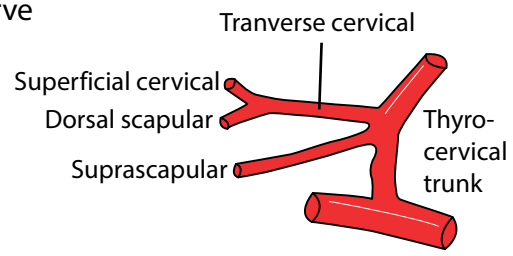
Relations of ascending aorta

Right: SVC, right auricle
Left: Pulmonary trunk
Posterior: Right main bronchus, right pulmonary artery, left atrium
Anterior: Sternum, pulmonary trunk, infundibulum of right ventricle



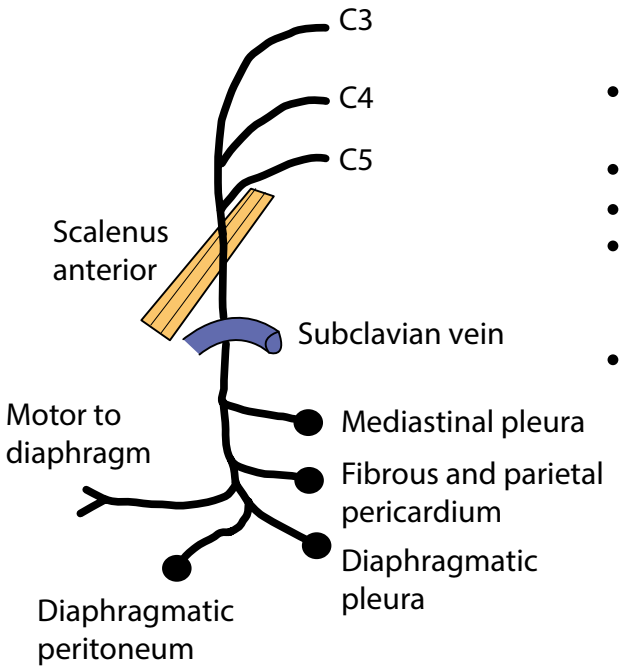
SUBCLAVIAN ARTERY
(branches from parts 3-2-0)

Variation in 1/3 people (branches 3-1-0)



It is only called "transverse cervical" if it gives origin to the "dorsal scapular artery" instead of the latter arising from the 2nd part of the

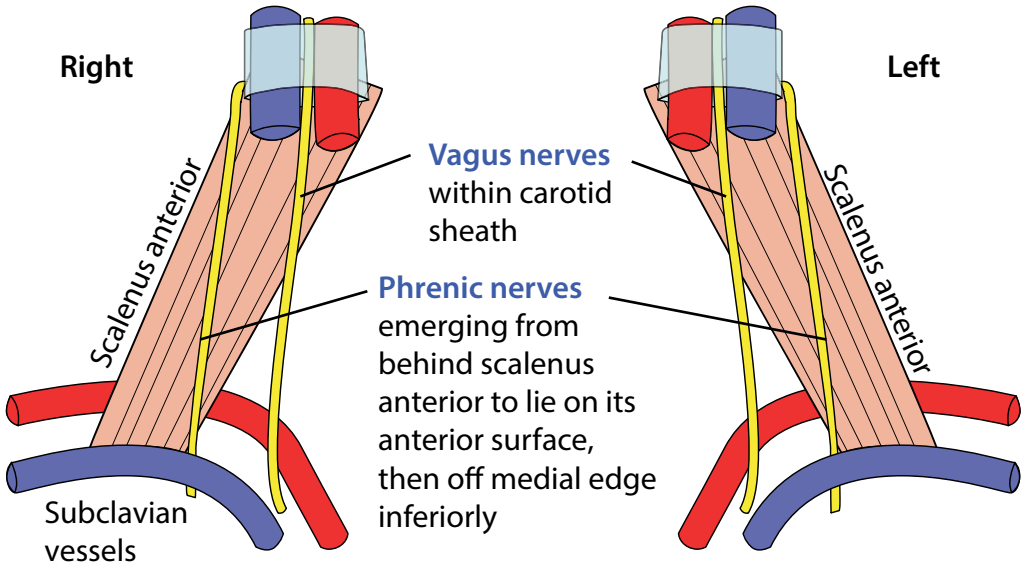
THE PHRENIC NERVE



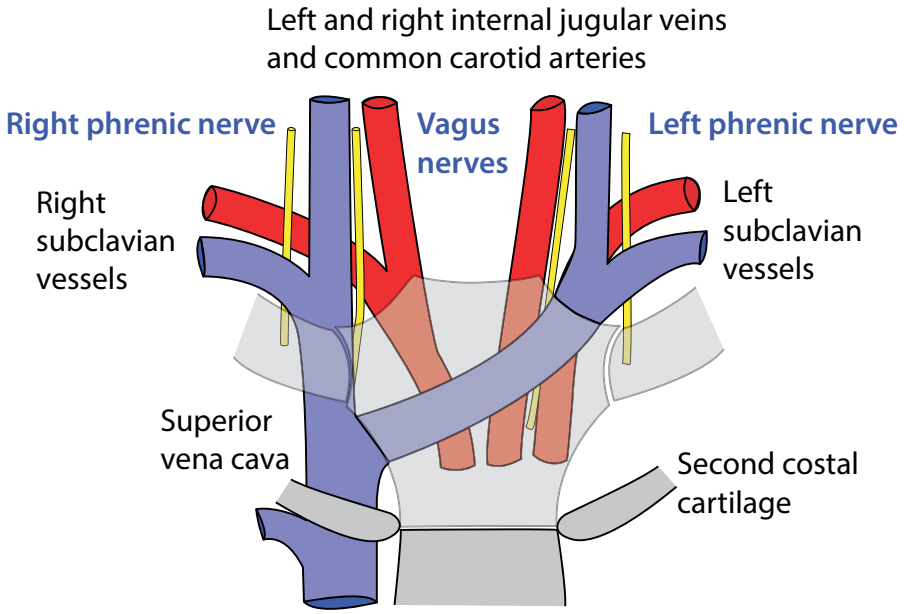
Notes:

- Phrenic nerve is the only motor supply to diaphragm.
- A third of its fibres are sensory.
- In the neck it lies on scalenus anterior.
- It passes into the thorax with the large veins anterior to it and the large arteries posterior to it.
- Pain detected by the phrenic nerve from the diaphragmatic peritoneum from an inflammed gall bladder is referred to C4 nerve distribution to the right shoulder tip via the supraclavicular nerves. There is no autonomic component to this type of referred pain.

VAGUS AND PHRENIC NERVES IN NECK



PHRENIC AND VAGUS NERVES ENTERING THE THORAX

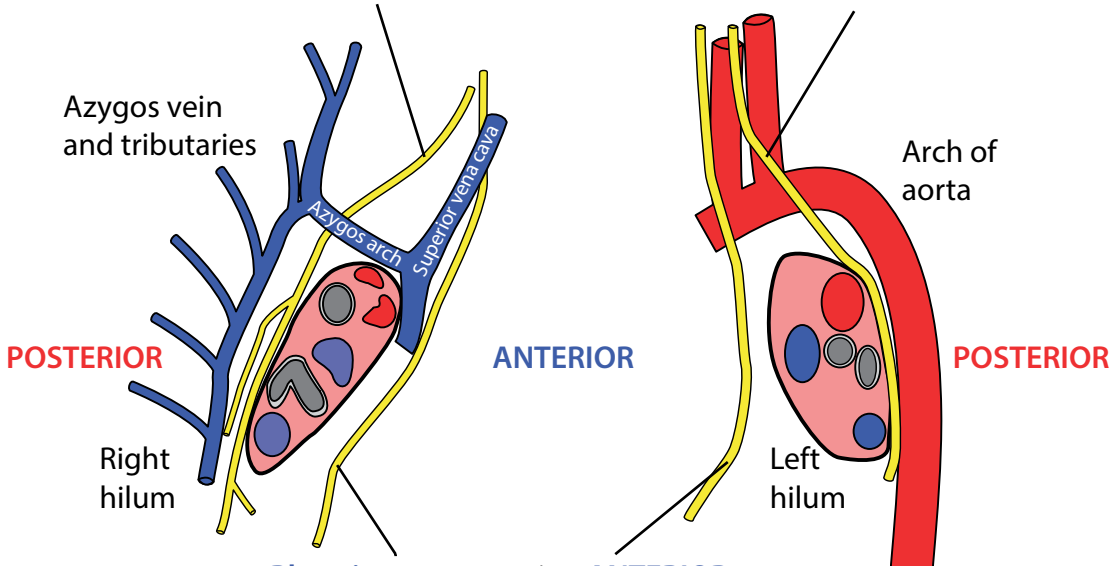


At the level of the thoracic inlet, both vagus and phrenic nerves enter the thorax between the veins anteriorly and the arteries posteriorly

RELATIONS OF PHRENIC AND VAGUS NERVES TO HILA OF LUNGS

Right vagus medial to azygos arch then **POSTERIOR** to hilum to reach oesophagus

Left vagus over arch of aorta then **POSTERIOR** to hilum to reach oesophagus



Phrenic nerves passing **ANTERIOR** to each hilum, lying on pericardium

THORACIC SYMPATHETICS

ALL SYMPATHETIC FIBRES ENTERING THE CHAIN FROM THE SPINAL CORD AS WHITE RAMI COMMUNICANTES SYNAPSE IN THE GANGLION FROM WHICH THEY LEAVE FOR DISTRIBUTION EXCEPT THOSE TO "GUT" AND ADRENAL GLAND.

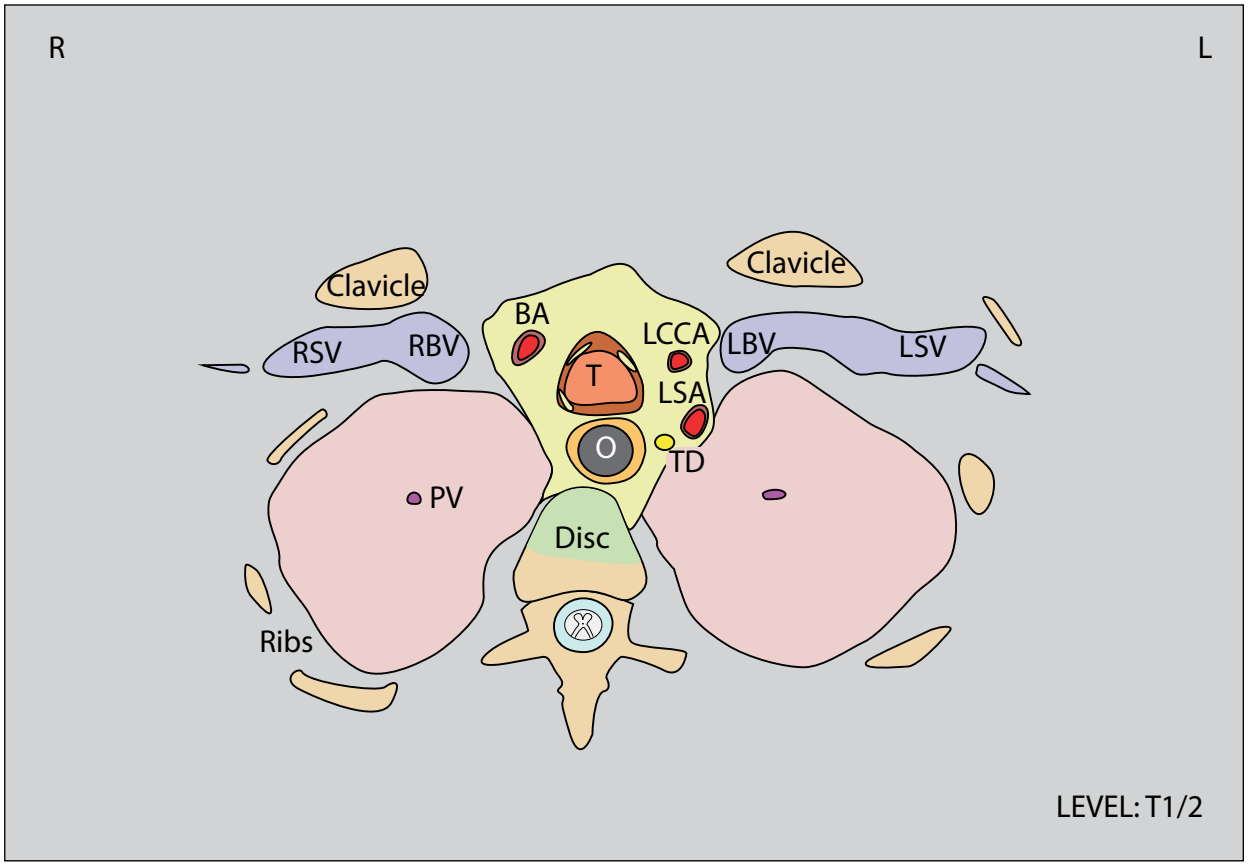
In practice this means that the splanchnic nerves (greater, lesser, least, lumbar and sacral) do not synapse until they reach their peripheral ganglia, whilst all others synapse in the chain ganglia.

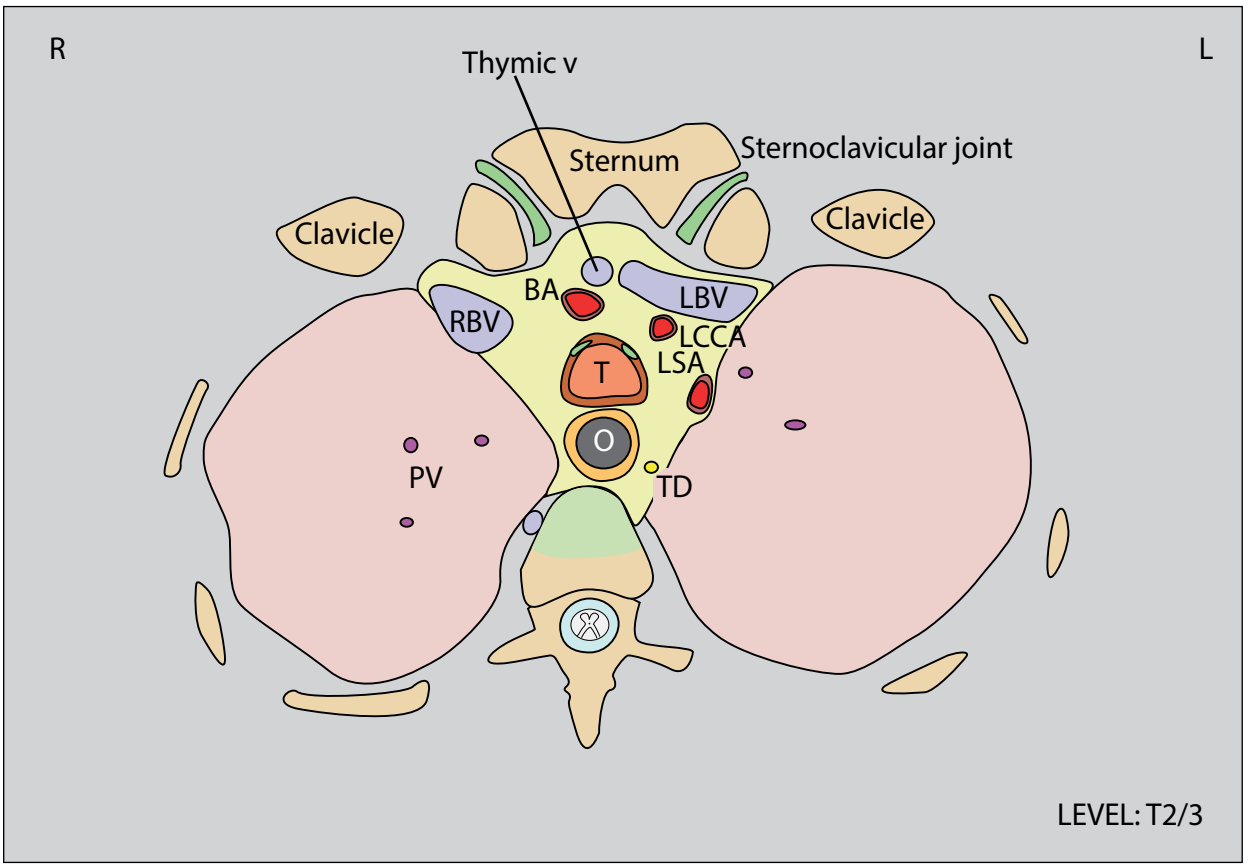
3.6 Cross Sections

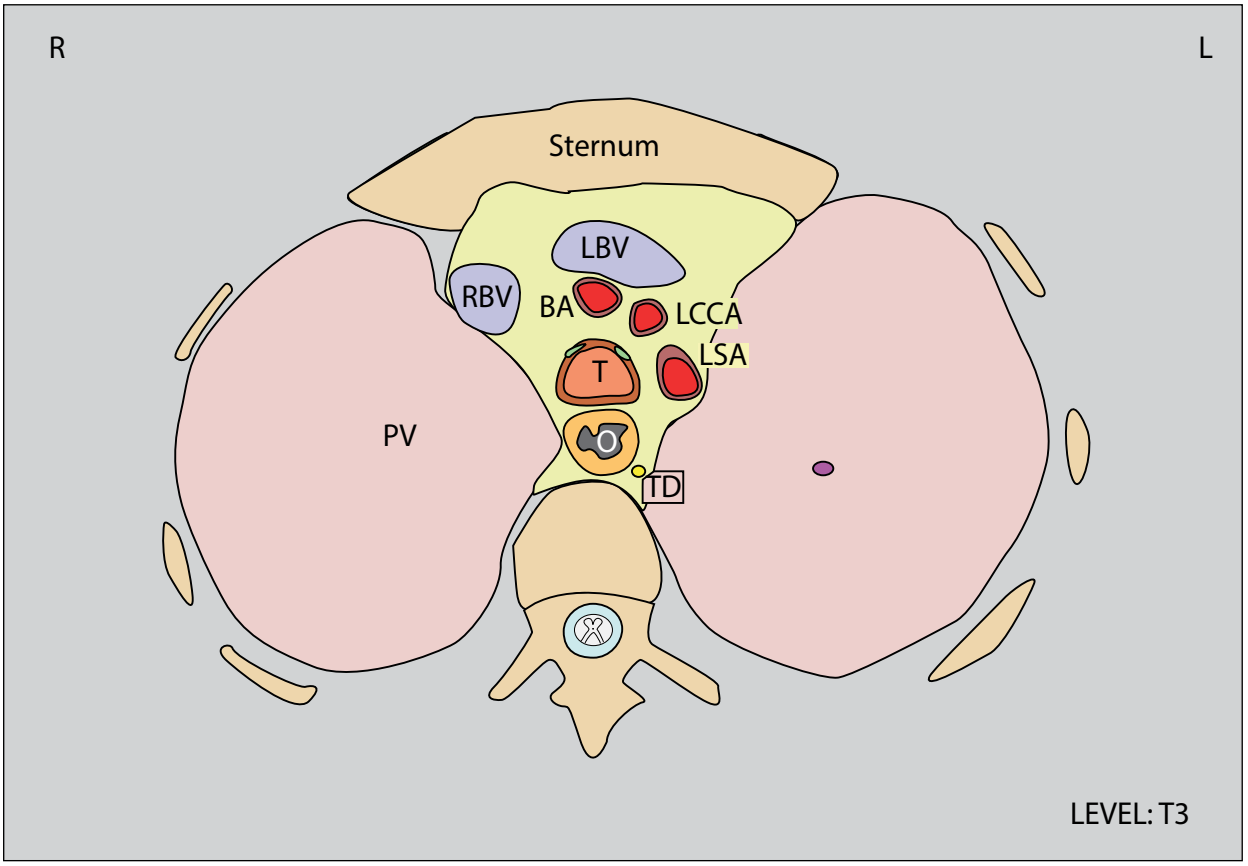
CROSS-SECTIONS OF THE THORAX BETWEEN T1 AND T10 VERTEBRAL LEVELS

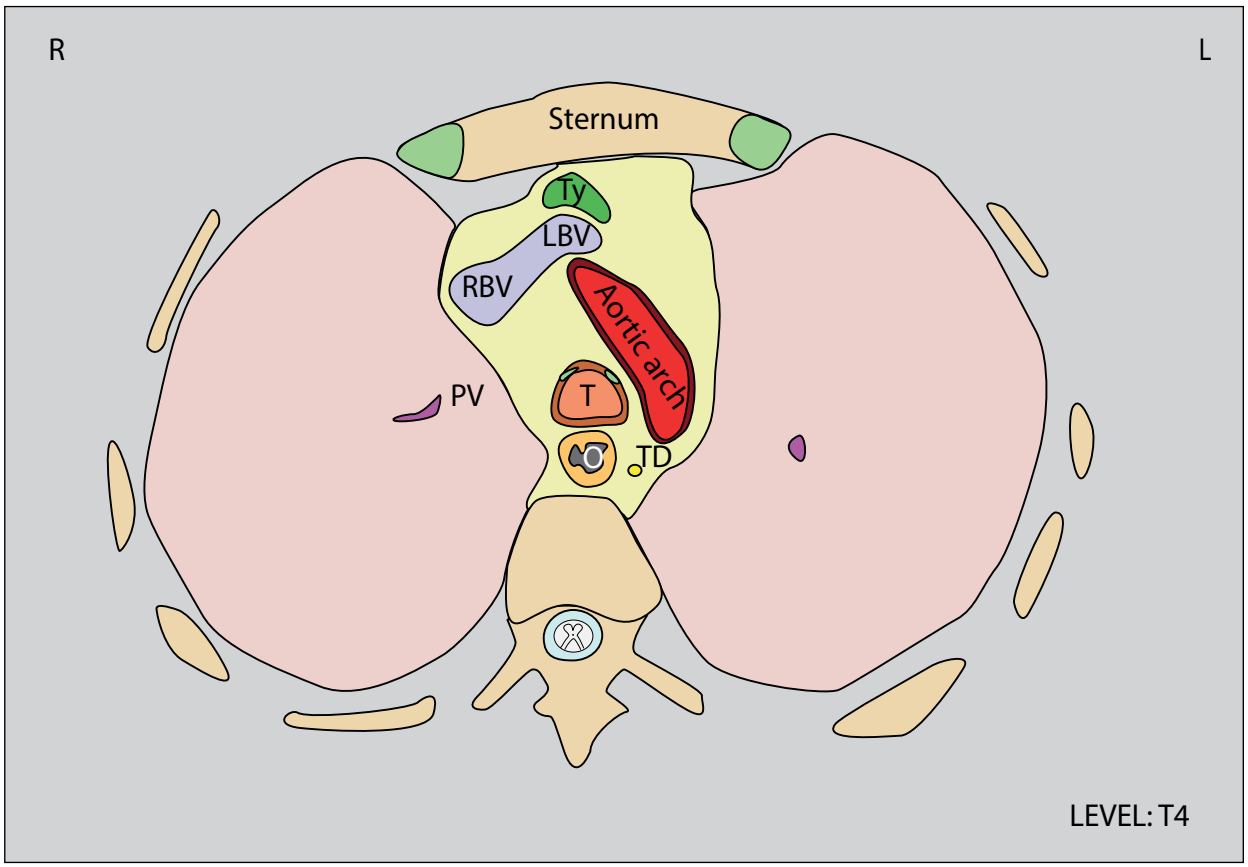
Key to abbreviations

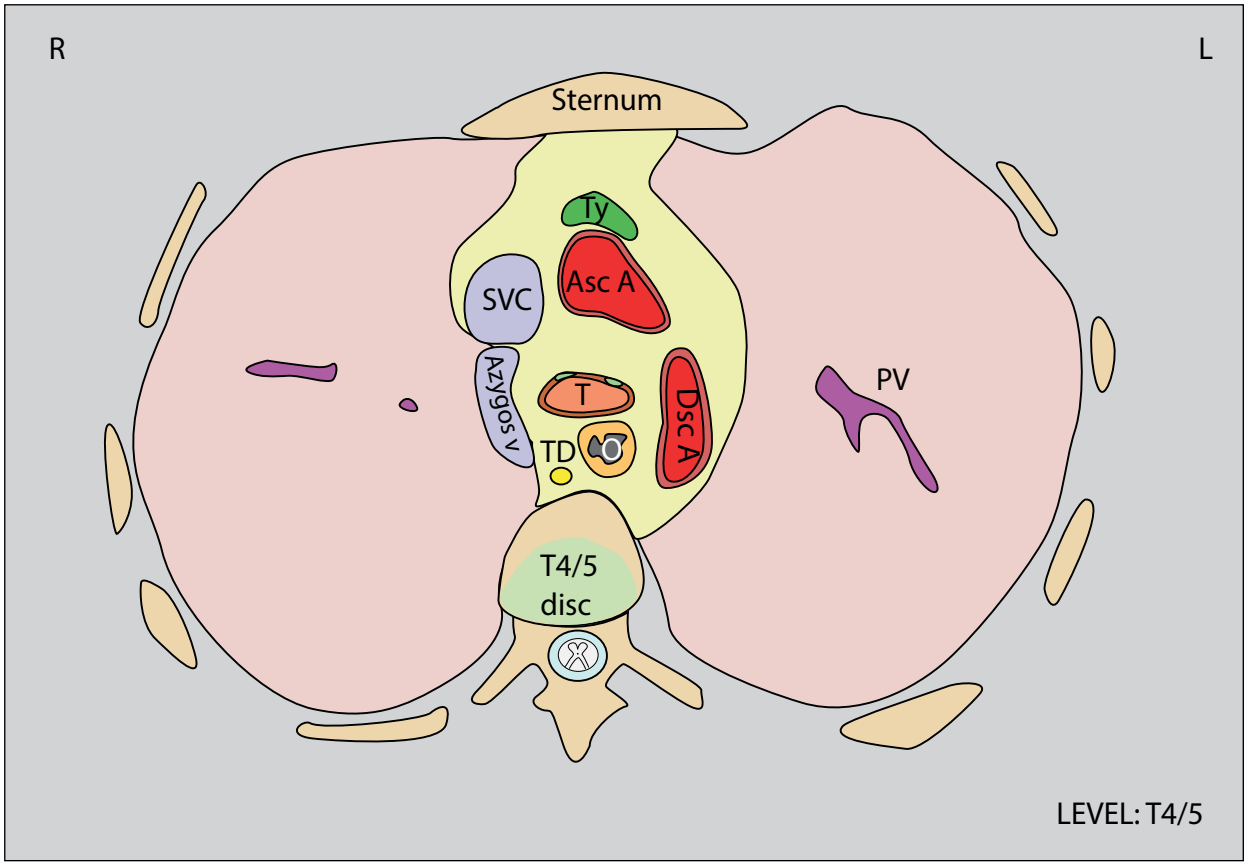
AscA	Ascending aorta
AV	Azygos vein
BA	Brachiocephalic artery
CS	Coronary sinus
CT	Crista terminalis
DscA	Descending aorta
IAS	Interatrial septum
LA	Left atrium/auricle
LB	Left bronchus
LBV	Left brachiocephalic vein
LCCA	Left common carotid artery
LPA	Left pulmonary artery
LSA	Left subclavian artery
LSV	Left subclavian vein
LV	Left ventricle
MB	Moderator band
MV	Mitral valve
O	Oesophagus
PT	Pulmonary trunk
PV	Pulmonary veins
RA	Right atrium/auricle
RB	Right bronchus
RBV	Right brachiocephalic vein
RPA	Right pulmonary artery
RSV	Right subclavian vein
RV	Right ventricle
SVC	Superior vena cava
T	Trachea
TD	Thoracic duct
TV	Tricuspid valve
TY	Thymus
V	Valve of IVC

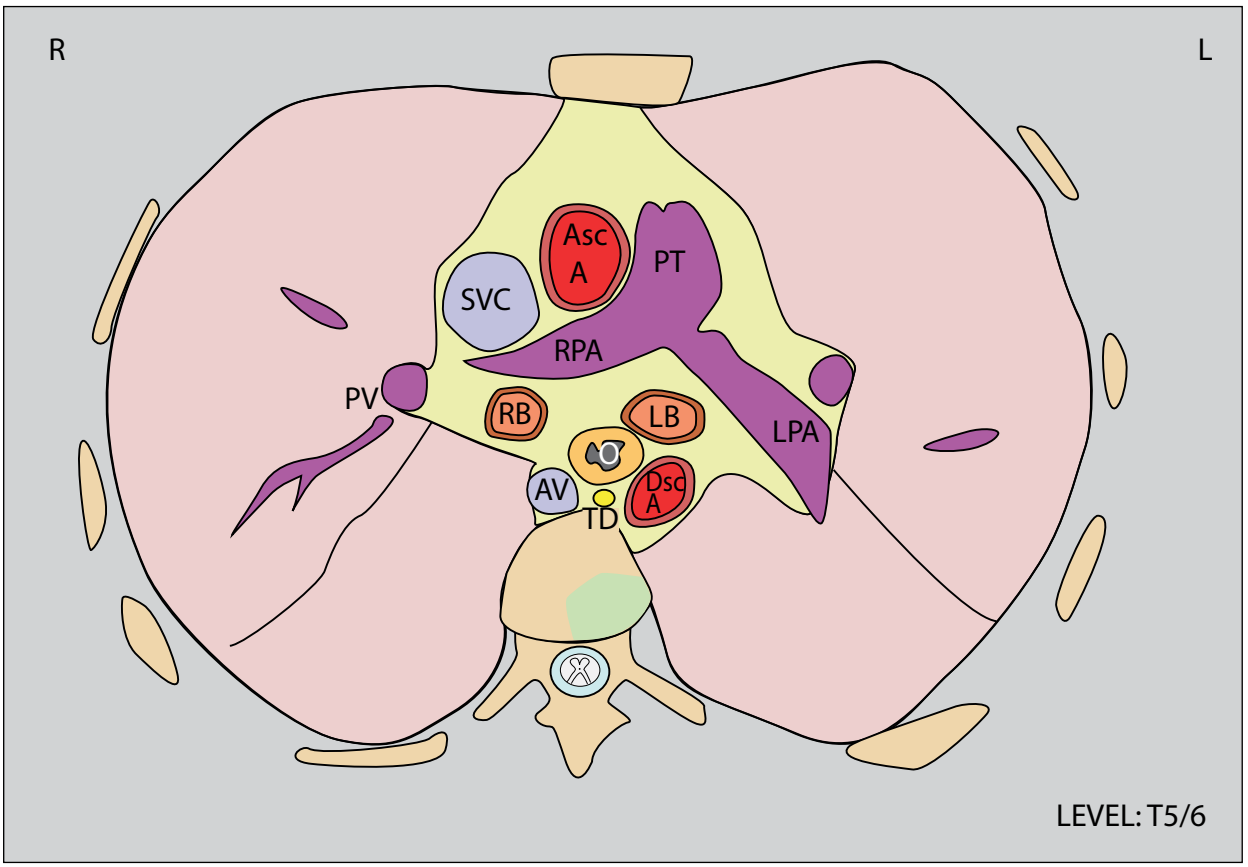


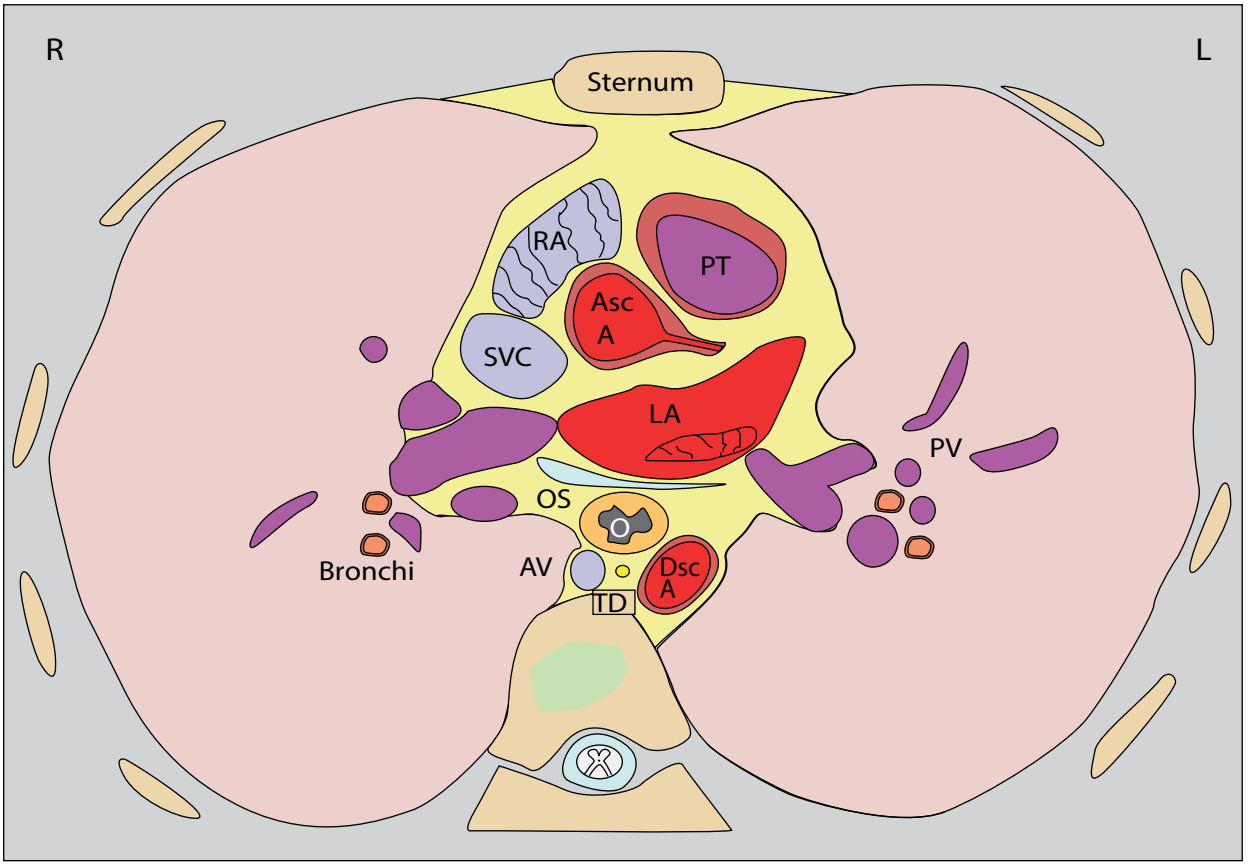

R
L
Thymic v
Sternum
Sternoclavicular joint
Clavicle
Clavicle
BA
LBV
RBV
LCCA
LSA
T
O
PV
TD
LEVEL: T2/3

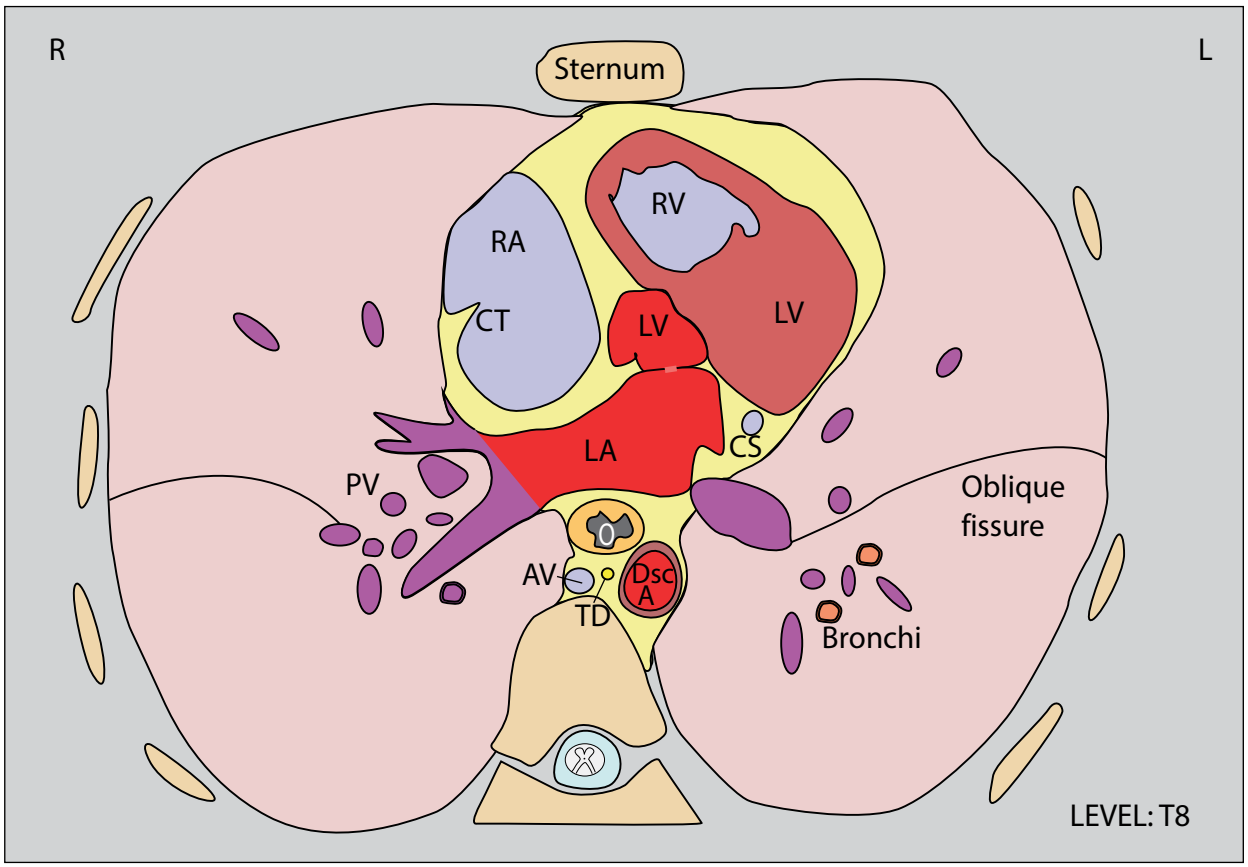

R
L
Sternum
LBV
RBV
BA
LCCA
LSA
T
PV
O
TD
LEVEL: T3

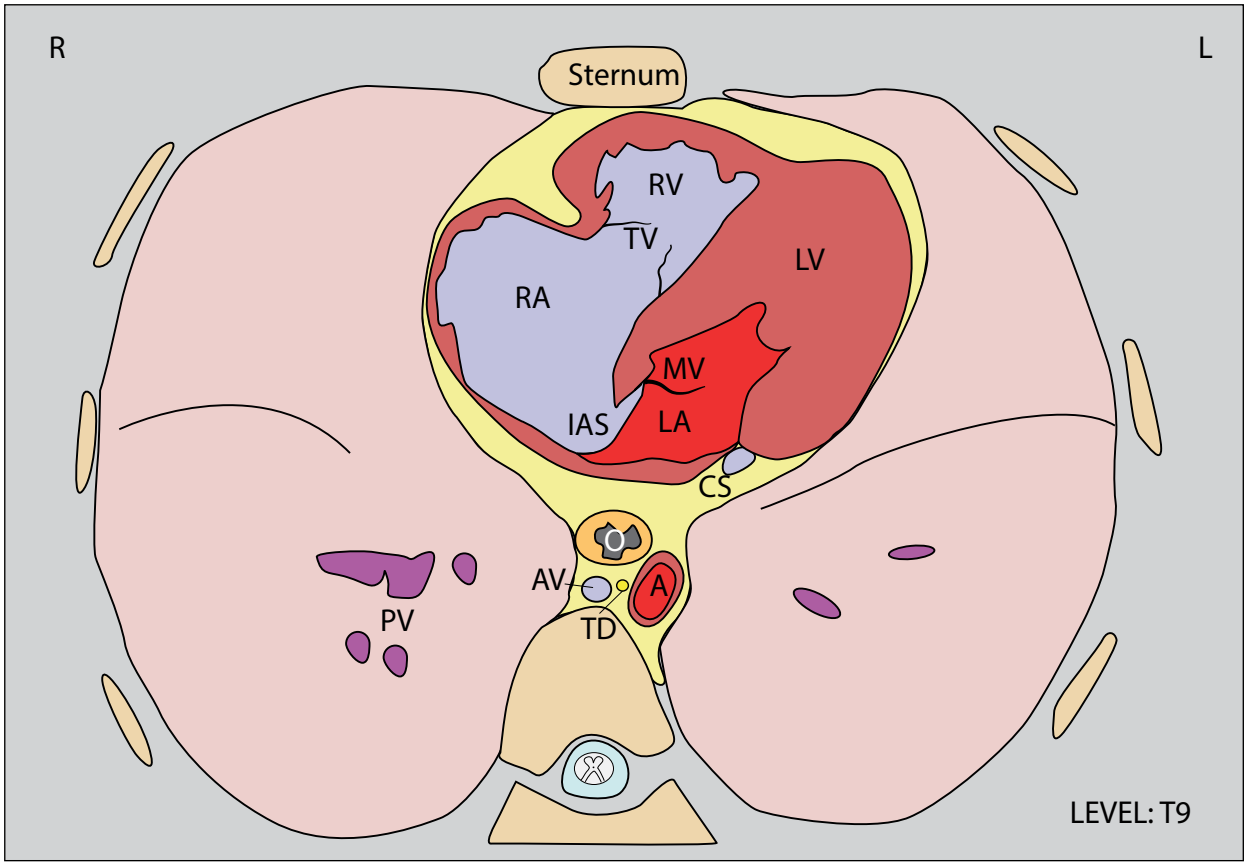

R
L
Sternum
Ty
LBV
RBV
Aortic arch
PV
T
TD
LEVEL: T4

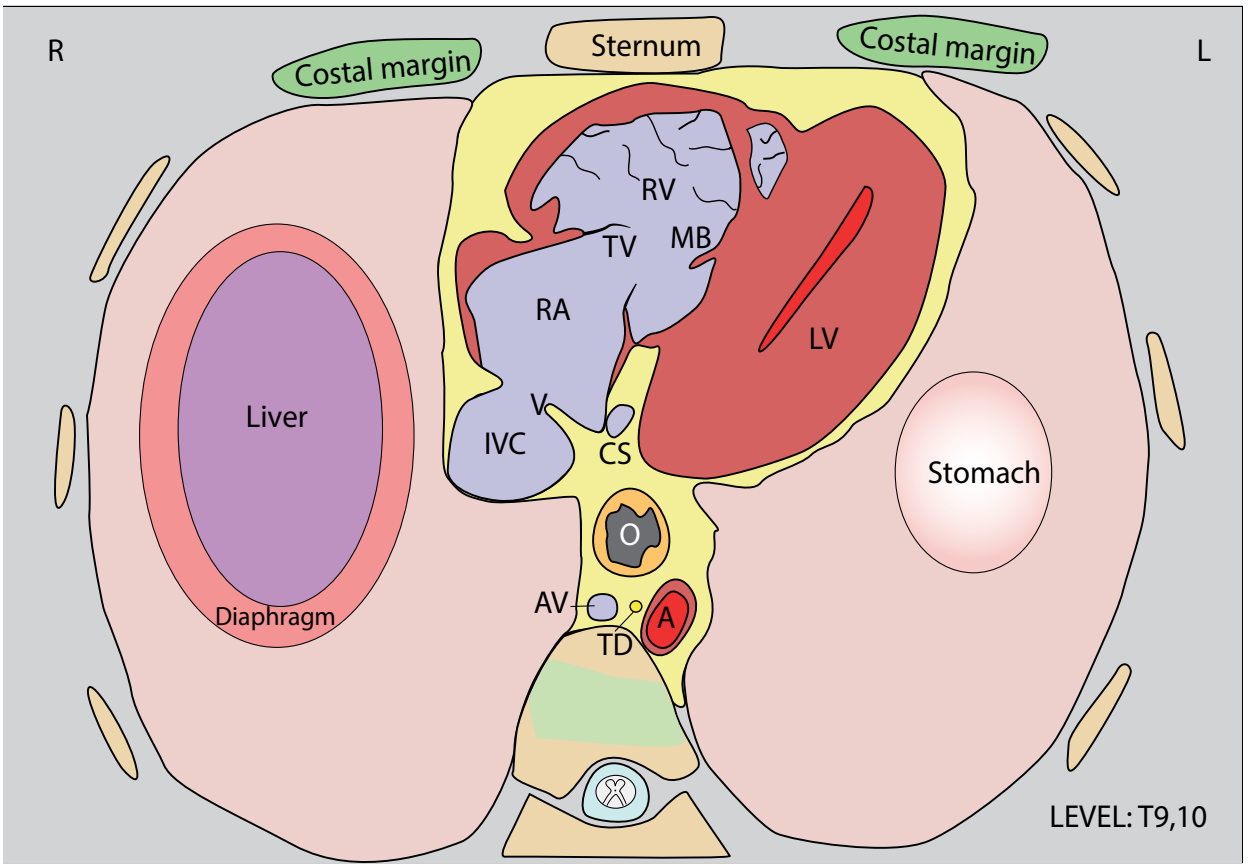

R
L
Sternum
Ty
Asc A
SVC
Azygos v
T
TD
Dsc A
PV
T4/5
disc
LEVEL: T4/5


R
L
Asc A
PT
SVC
RPA
PV
RB
LB
LPA
AV
Dsc A
TD
LEVEL: T5/6

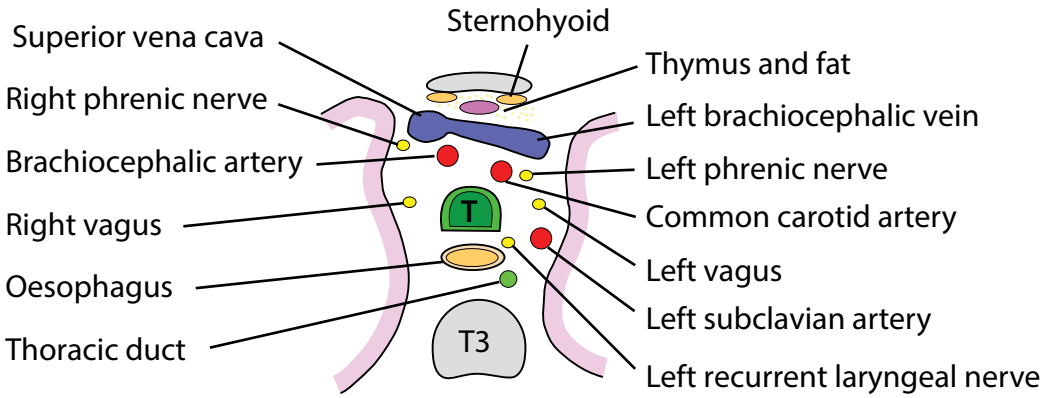

R
L
Sternum
RA
PT
Asc A
SVC
LA
PV
OS
Bronchi
AV
Dsc A
TD


R
L
Sternum
RV
RA
CT
LV
LV
LA
CS
PV
Oblique
fissure
AV
Dsc
A
TD
Bronchi
LEVEL: T8

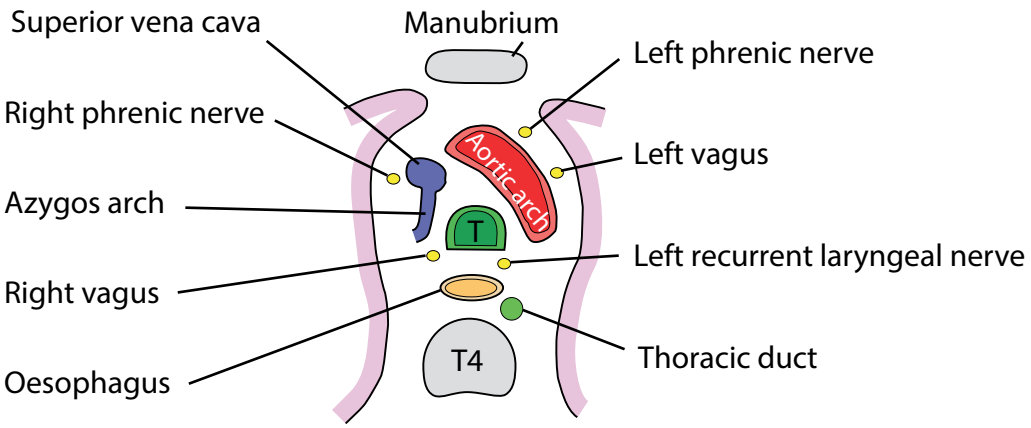

R
L
Sternum
RV
TV
LV
RA
MV
IAS
LA
CS
AV
A
PV
TD
LEVEL: T9



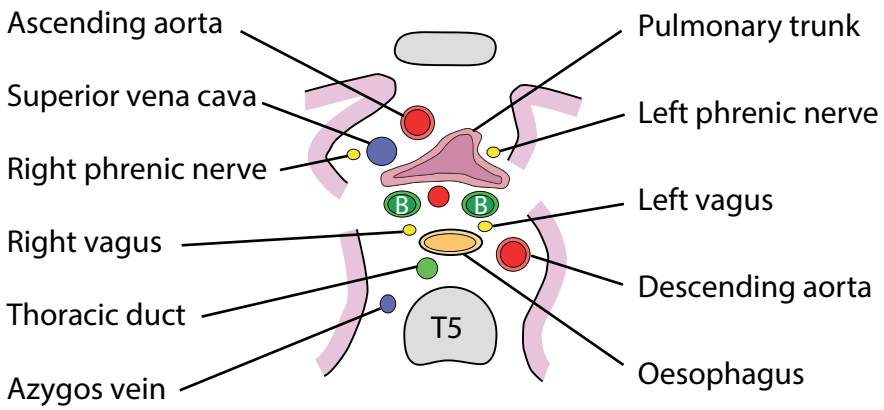
CROSS (AXIAL) SECTIONS OF MEDIASTINUM AT T3 (LOOKING UP)



CROSS (AXIAL) SECTIONS OF MEDIASTINUM AT T4 (LOOKING UP)



CROSS (AXIAL) SECTIONS OF MEDIASTINUM AT T5 (LOOKING UP)



SECTION 4

Abdomen and Pelvis

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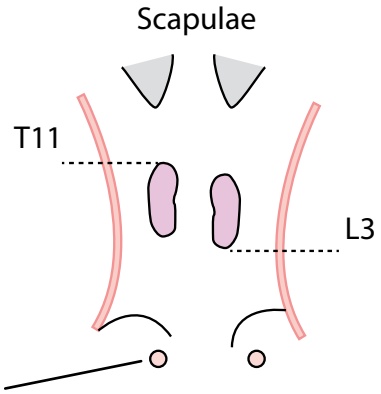
4.1 Surface Anatomy and Hernia

SURFACE ANATOMY OF POSTERIOR ABDOMINAL WALL

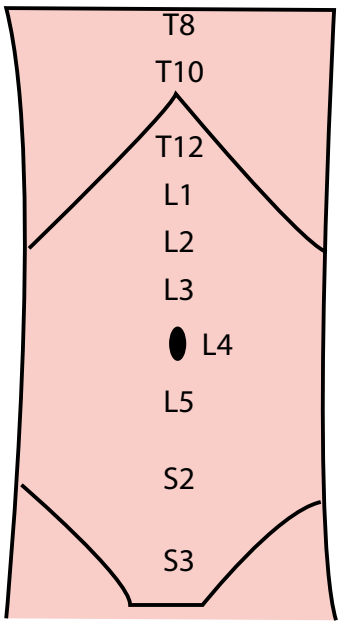


Hila of kidneys are 5cm from midline

Sacral dimples (S2)

- Mid point of sacro-iliac joints
- End of dural sac
- Posterior superior iliac spine

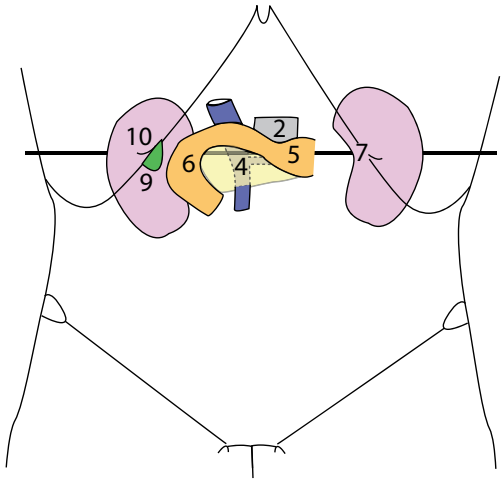
VERTEBRAL LEVELS



T8	Caval opening (diaphragm); right phrenic nerve
T10	Oesophageal opening (diaphragm); branches of left gastric vessels to lower oesophagus; vagus nerves)
T12	Aortic opening (diaphragm); aorta; ascending lumbar veins becoming azygos veins; cisterna chyli becoming thoracic duct; coeliac axis/trunk
L1	Transpyloric plane; superior mesenteric artery
L1/2	Spinal cord ends; renal arteries
L2	Subcostal plane; gonadal arteries
L3	Inferior mesenteric artery
L3/4	Umbilicus
L4	Bifurcation of aorta; supracristal plane
L5	Formation of vena cava
S2	Sacral dimple; mid point of sacroiliac joint; end of dural sac: lower attachment of small bowel mesentery
S3	Start of rectum

TRANSPYLORIC PLANE

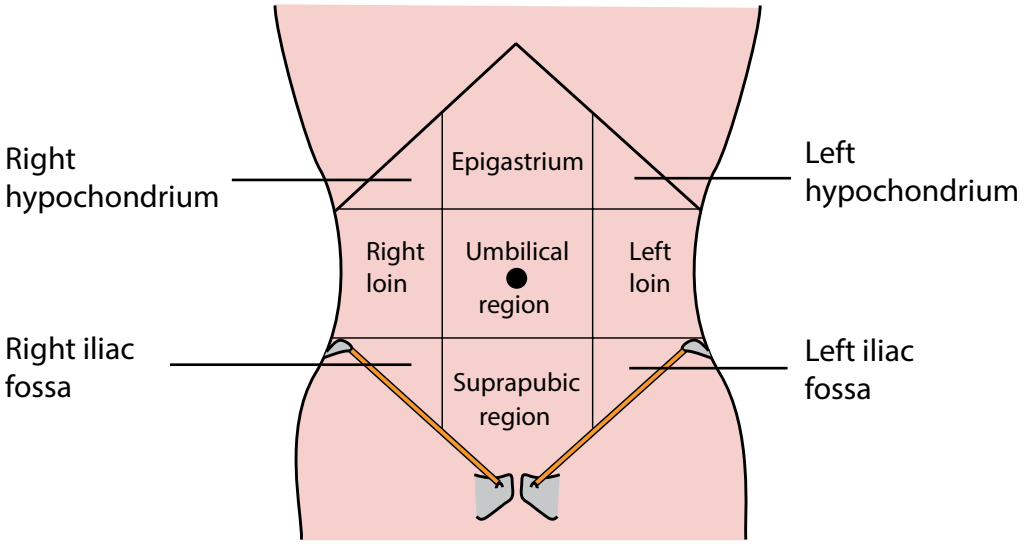
(Horizontal line half way between suprasternal notch and pubic symphysis)



Structures approximately on this line:

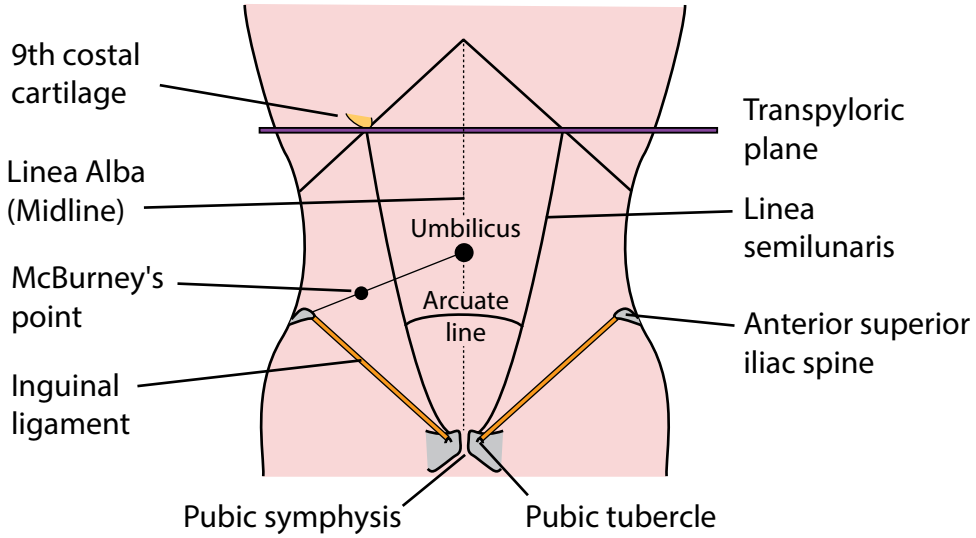
1 End of spinal cord
2 L1 vertebral body
3 Origin of superior mesenteric artery
4 Origin of portal vein and neck of pancreas
5 Pylorus of the stomach
6 Second part of duodenum and Sphincter of Oddi
7 Hilum of each kidney
8 Duodenojejunal flexure
9 Fundus of gall bladder
10 Tips of ninth costal cartilages

REGIONS OF ABDOMEN



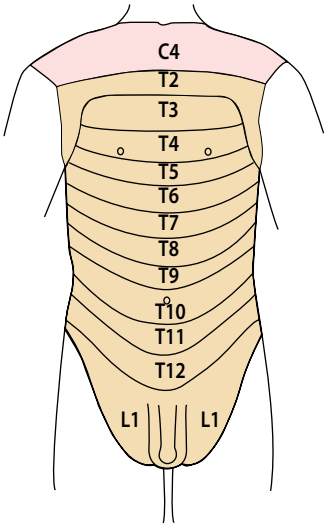
For descriptive purposes, both anatomically and clinically, the abdomen is divided into 9 regions by 2 horizontal and 2 vertical lines. Books tend to define these lines but, in reality and because of human variation in shape and size, the lines are arbitrary.
An alternative method, often used clinically, is simply to divide the abdomen into 4 quadrants, upper, lower, left and right, with 2 loins posteriorly

SURFACE MARKINGS ON ABDOMINAL WALL



Transpyloric plane: Half way between suprasternal notch and symphysis pubis
Inguinal ligament: Anterior superior iliac spine to pubic tubercle
Arcuate line: 3-5cm inferior to umbilicus
Linea semilunaris: Lateral edge of rectus sheath
McBurney's point: One third along a line from ASIS to umbilicus. Incision site for appendicectomy

DERMATOMES OF THORAX AND ABDOMEN



Dermatomes

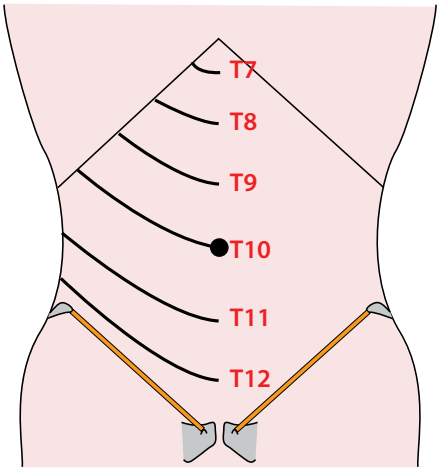
T4: nipples

T6: xiphoid

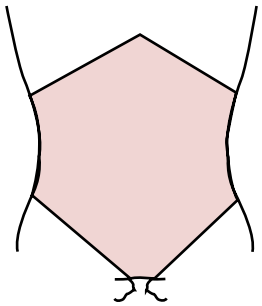
T10; umbilicus

T12: pubis

DERMATOMES OF ABDOMEN

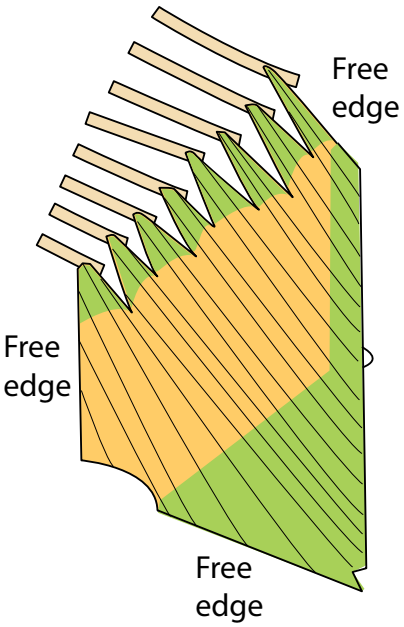


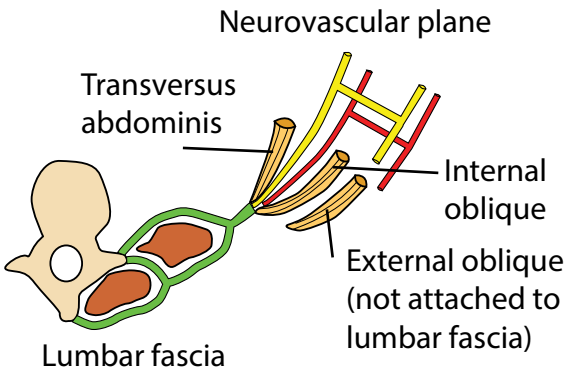
LAYERS OF THE ABDOMINAL WALL



1 Skin
2 Fat
3 Camper's fascia (superficial layer of superficial fascia - thin)
4 Fat
5 Scarpa's fascia (deep layer of superficial fascia - thick)
6 Fat
7 Aponeurosis
8 Three muscles
9 Transversalis fascia
10 Peritoneum

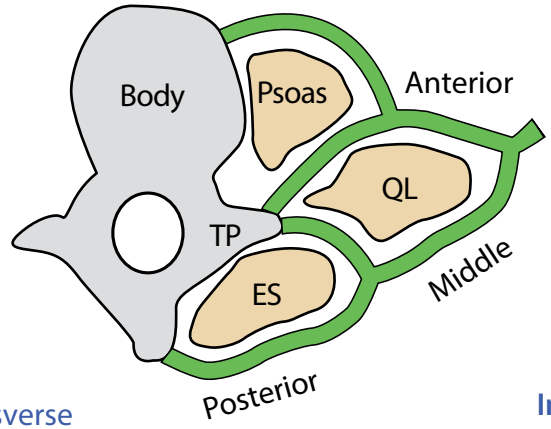
ABDOMINAL WALL MUSCLES 1





EXTERNAL OBLIQUE
From: Anterior angles last 8 ribs.
To: Xiphisternum, linea alba, pubic symphysis and crest, inguinal ligament, anterior 1/2 iliac crest.
Fibres: Run down/medial
Nerves: T7-12

LAYERS OF THORACOLUMBAR FASCIA

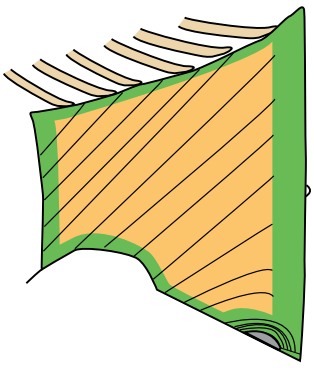


Attachment of transversus and internal oblique **Note:** External oblique does not reach to this fascia

TP= Transverse process
ES= Erector spinae
QL= Quadratus lumborum

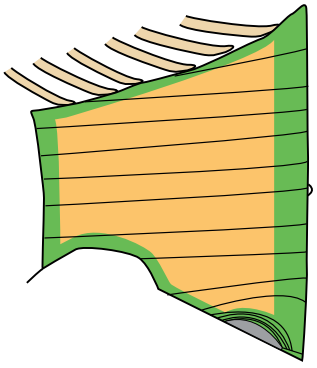
In the lumbar region all 3 layers are present. In the thoracic region there is a posterior layer only

ABDOMINAL WALL MUSCLES 2



INTERNAL OBLIQUE

From: Anterior 2/3 iliac crest, lateral 2/3 inguinal ligament, lumbar fascia
To: Costal margin, rectus sheath. Conjoint tendon (CT) on pubic crest and pectineal line.
Fibres: Run upward/medial
Nerves: T7-12, ilioinguinal to CT

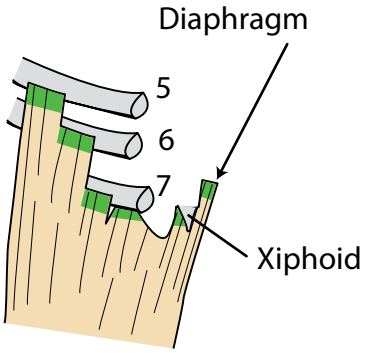


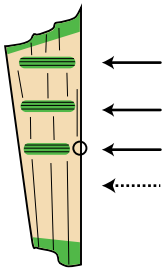
TRANSVERSUS ABDOMINIS

From: Costal margin, lumbar fascia, anterior 2/3 iliac crest, lateral 1/2 inguinal ligament
To: Rectus sheath, linea alba, CT to pubic crest and pectineal line
Fibres: Transverse
Nerves: T7-12, ilioinguinal to CT

ABDOMINAL WALL MUSCLES
RECTUS ABDOMINIS

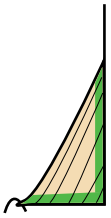
RECTUS ABDOMINIS
From: Pubic crest, tubercle and symphysis pubis
To: Costal cartilages 5,6,7 and costal margin of rib 7, sternum and diaphragm
Nerve: T7-12
(Note: 3 morphological layers)

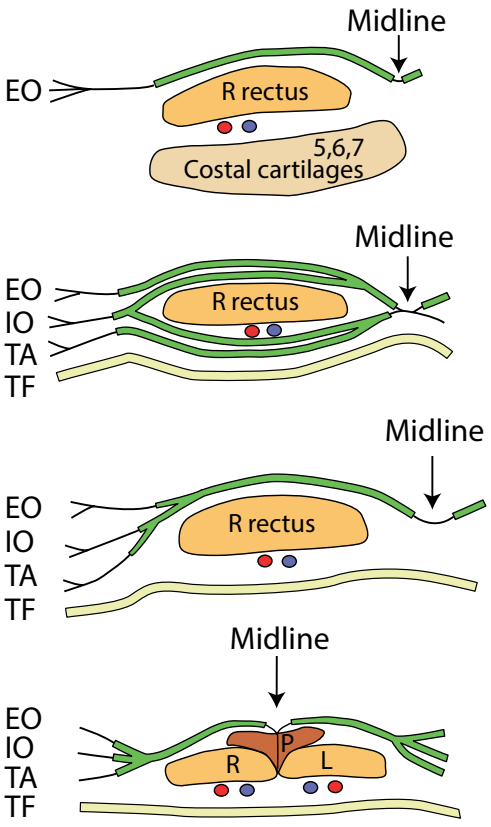




3 Tendinous intersections (rarely 4)
Fusion to anterior sheath

PYRAMIDALIS
From: Anterior of body of pubic symphysis
To: Linea alba
Nerve: T12 (subcostal)



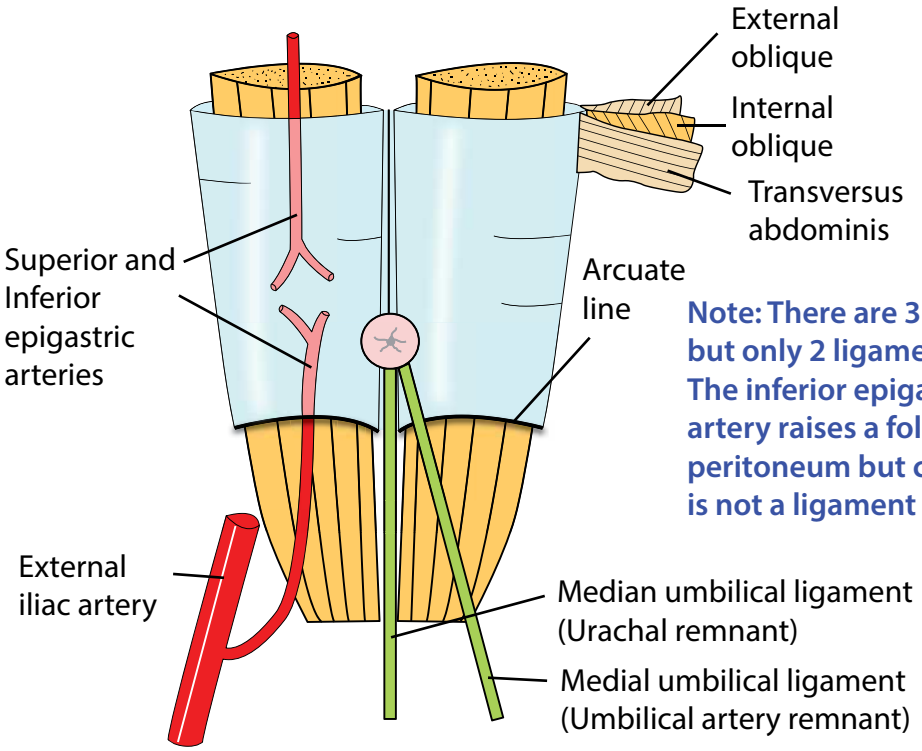


ABDOMINAL WALL MUSCLES - RECTUS SHEATH

EO External oblique
IO Internal oblique
TA Transversus abdominis
TF Transversalis fascia
P Pyramidalis

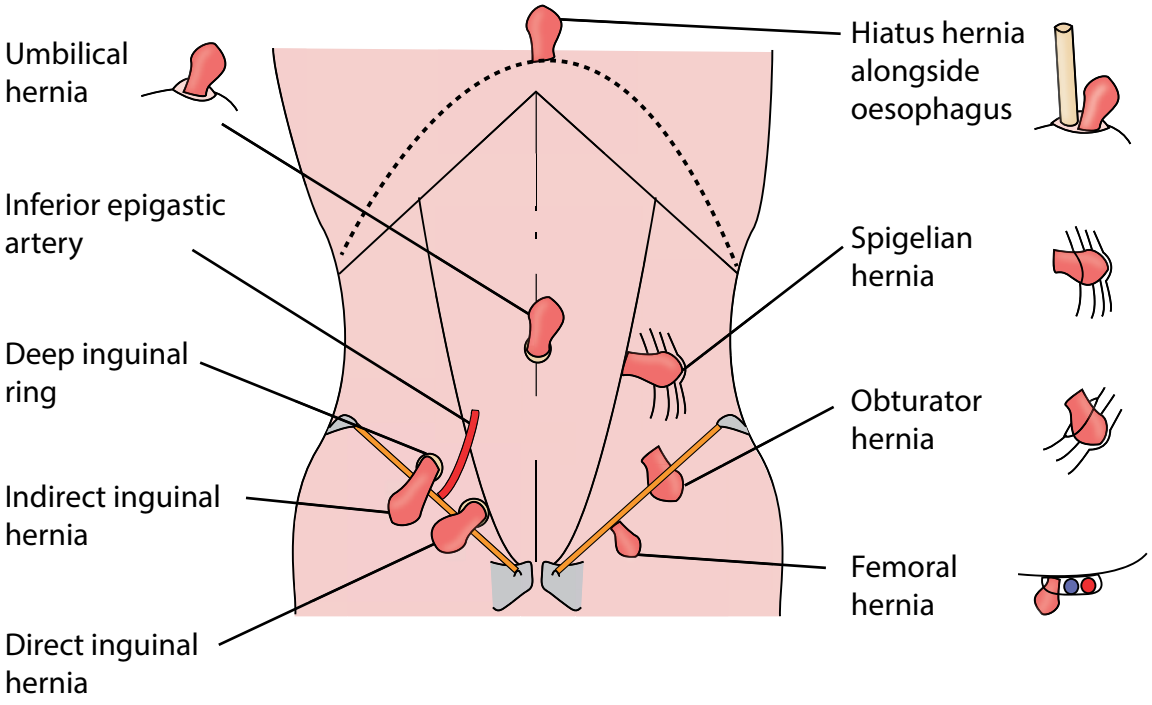
Actions of abdominal muscles:
- Truncal movements
- Rib depression
- Visceral support

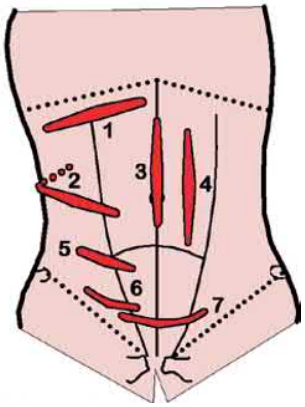
INFERIOR RECTUS SHEATH (posterior view)



Note: There are 3 folds but only 2 ligaments. The inferior epigastric artery raises a fold of peritoneum but clearly is not a ligament

HERNIAL SITES



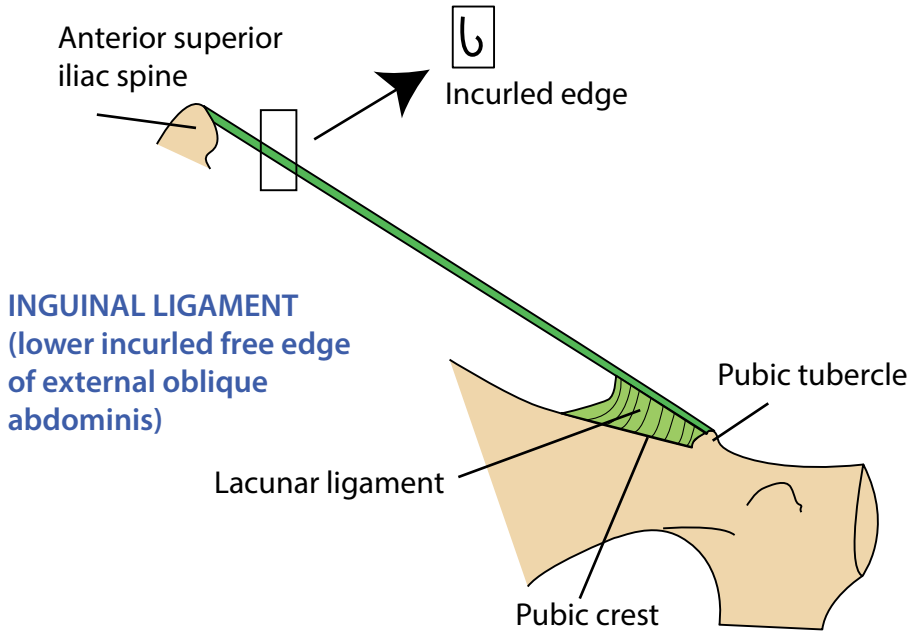


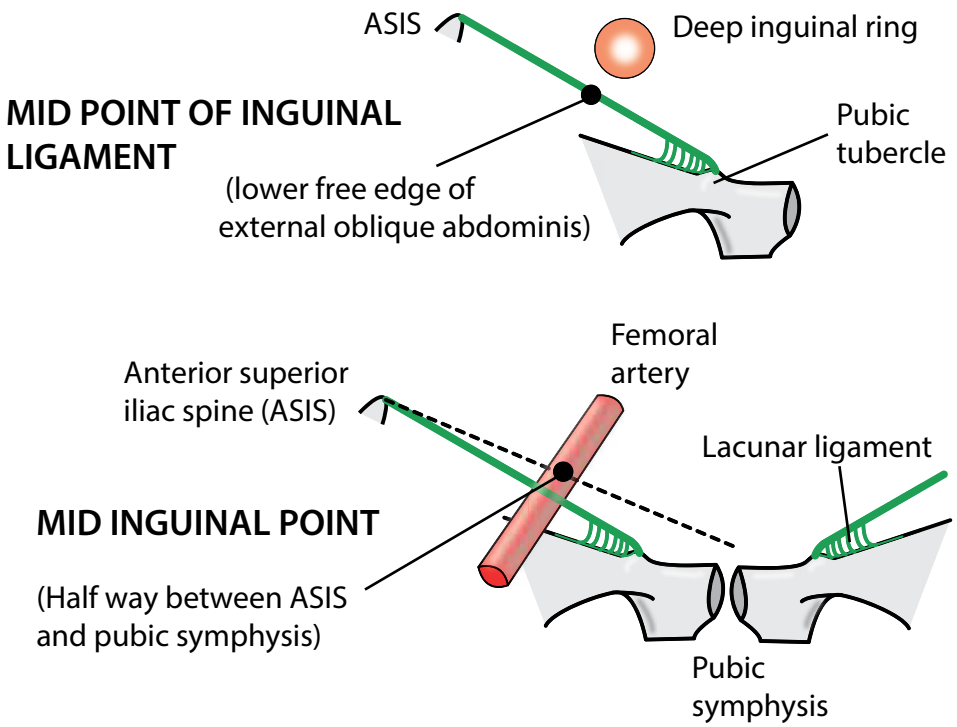
ABDOMINAL INCISIONS

Surgical Access
The more anterior the incision the poorer the blood supply and the worse the healing, but the less nerve and muscle damage. Vice versa for more posterior incisions

1	Subcostal	Muscle cutting	Gall bladder
2	Loin	Muscle cutting	Kidney/ureter
3	Midline	Between rectus sheaths	Upper/lower abdomen
4	Paramedian	Rectus sheath cutting	General
5	Grid iron	Muscle splitting	Appendix
6	Inguinal	Rectus sheath splitting	Hernia
7	Suprapubic	Sheath/muscle cutting	Pelvic organs

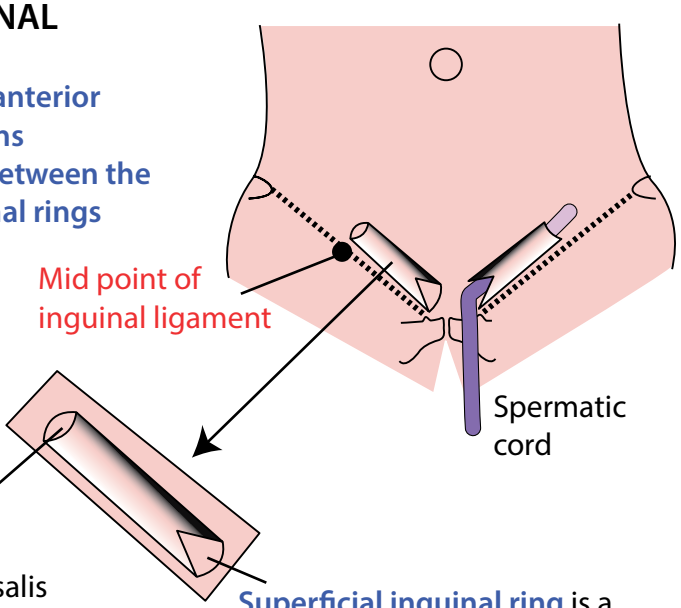
RIGHT INGUINAL LIGAMENT





INGUINAL CANAL

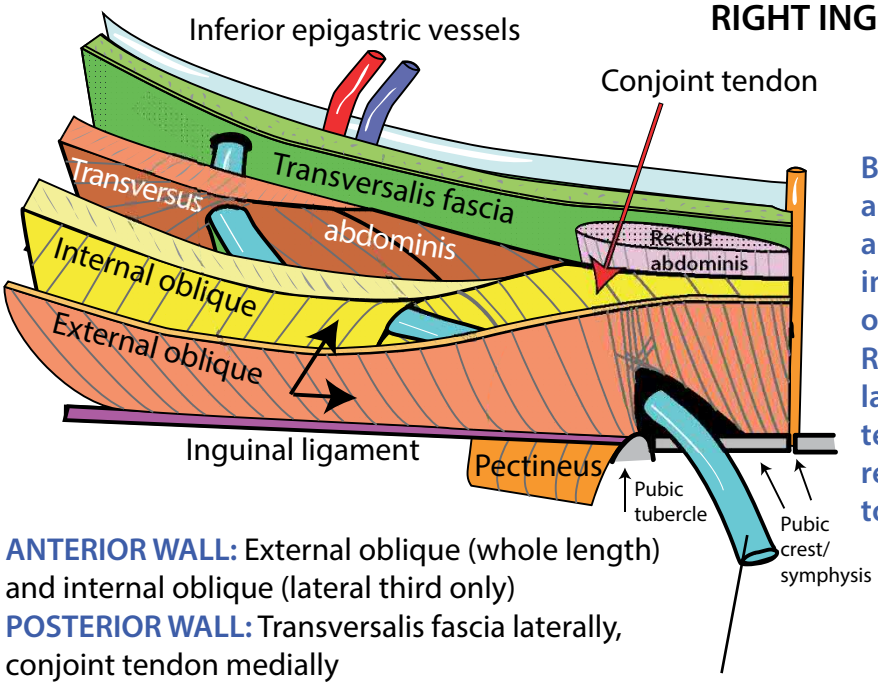
A 4cm tunnel in the lower, anterior abdominal muscles that runs downwards and medially between the deep and superficial inguinal rings



Deep inguinal ring is a hole in the transversalis fascia lying 3cm superior to the mid point of the inguinal ligament

Superficial inguinal ring is a V-shaped defect in the lower, medial fibres of the external oblique, just superior and lateral to the pubic tubercle

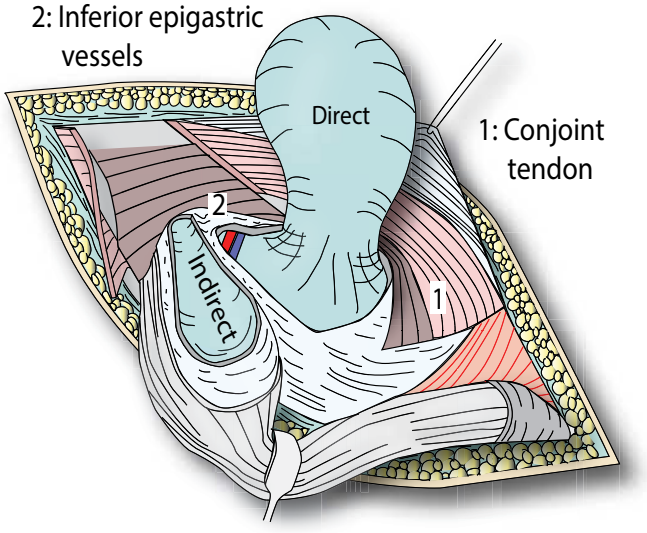
RIGHT INGUINAL CANAL



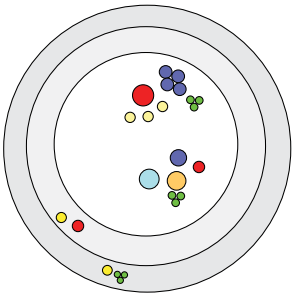
Black arrows show 2 areas of "reinforcement" anterior to deep ring - internal and external oblique.
Red arrow shows the two layers of the conjoint tendon giving reinforcement posterior to the superficial ring

ANTERIOR WALL: External oblique (whole length) and internal oblique (lateral third only)
POSTERIOR WALL: Transversalis fascia laterally, conjoint tendon medially
ROOF: Curved fibres of internal oblique and tranversus abdominis
FLOOR: Inguinal ligament

INGUINAL HERNIAS AND SPERMATIC CORD

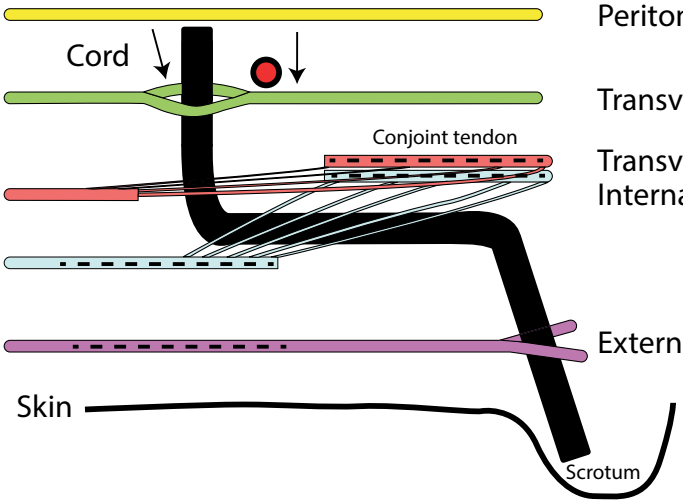


SPERMATIC CORD. Contents:
1. 3 arteries (testicular, cremasteric, artery to vas)
2. 3 veins (as above)
3. 3 fascia (internal, spermatic, external)
4. 3 nerves (ilio-inguinal, genital branch of genitofemoral, sympathetics)
5. 3 others (vas, processus vaginalis, lymphatics)



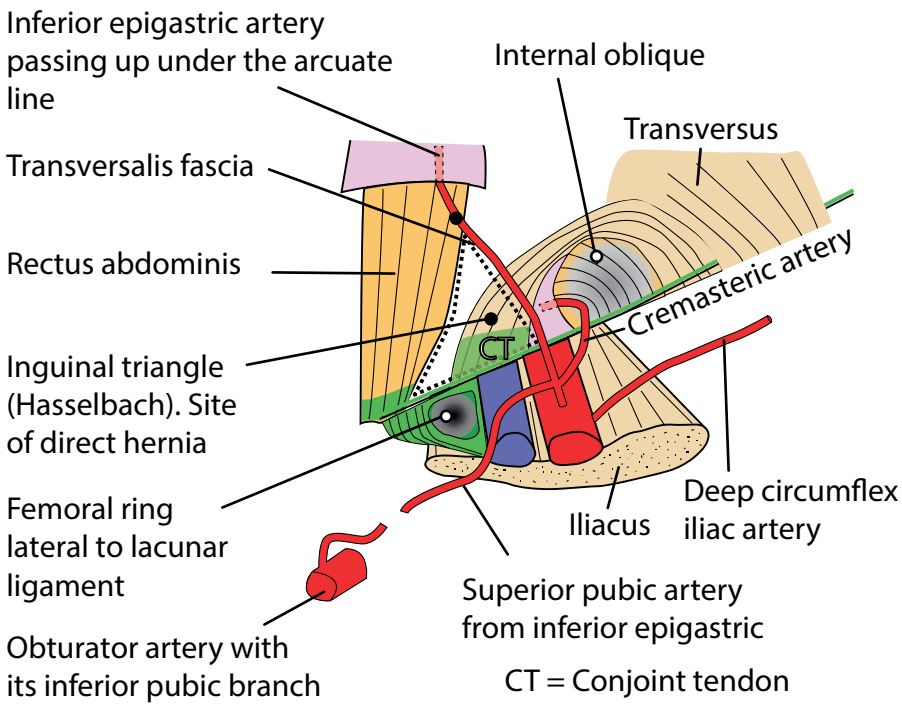
INDIRECT hernia though deep ring, lateral to inferior epigastric vessels. DIRECT hernia through transversalis fascia and conjoint tendon, medial to inferior epigastric vessels

"EXPLODED" RIGHT INGUINAL CANAL



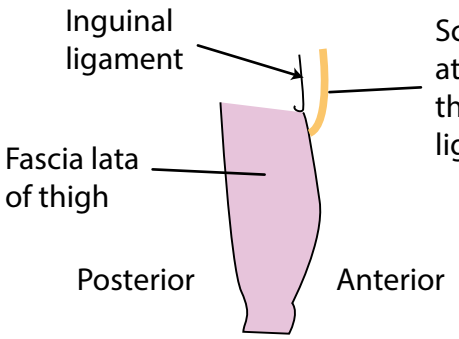
- Arrows indicate sites of weakness at deep ring (indirect hernia) and at transversalis fascia lateral to conjoint tendon (direct hernia).
- Dotted lines indicate the 2 layers that support both the deep and superficial inguinal rings.

ABDOMINAL WALL
RIGHT DEEP INGUINAL RING FROM INSIDE



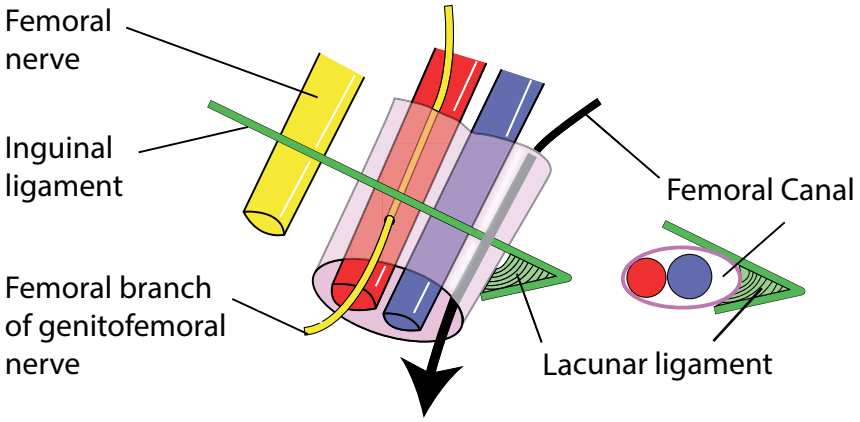
Note: If the obturator artery is missing then the superior pubic branch of the inferior epigastric takes over. This artery is then called an abnormal (aberrent) obturator artery. Whether or not an abnormal obturator artery is present, the superior pubic branch of the inferior epigastric may run anteromedial to the sac of a femoral hernia in the femoral ring. If so, it can easily be damaged during a hernia repair. In this illustration it runs posterolateral and is thus not a hazard

ABDOMINAL WALL - FASCIA OVER INGUINAL REGION



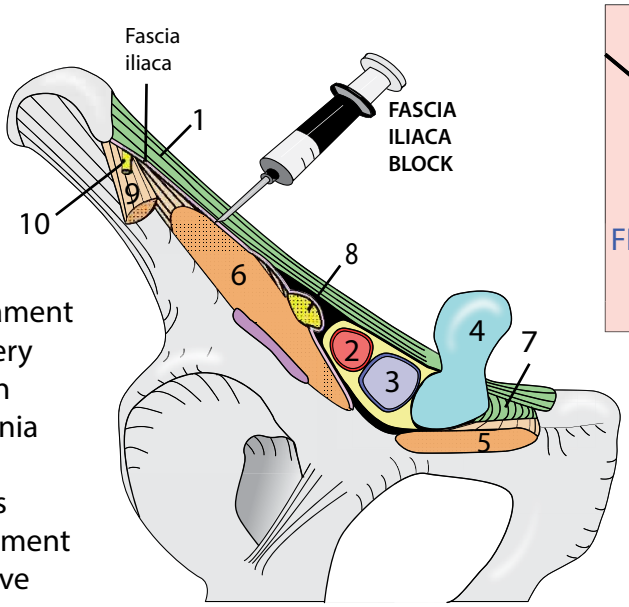
Scarpa's fascia is the deep layer of the superficial abdominal fascia

FEMORAL SHEATH AND CANAL

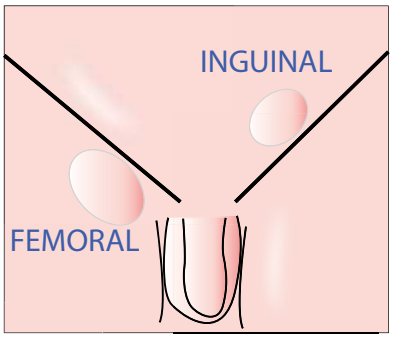


FEMORAL CANAL lies within the femoral sheath between the lacunal ligament (medial), femoral vein (lateral), pubic ramus (posterior) and inguinal ligament (anterior). It transmits all the lower limb lymphatics and allows expansion of the femoral vein during high venous return. **A FEMORAL HERNIA** passes downwards through the canal and can be released by cutting the lacunar ligament.

FEMORAL HERNIA

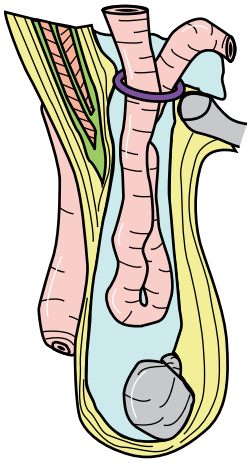


1. Inguinal ligament
2. Femoral artery
3. Femoral vein
4. Femoral hernia
5. Pectineus
6. Psoas/iliacus
7. Lacunar ligament
8. Femoral nerve
9. Sartorius
10. Lateral femoral cutaneous nerve

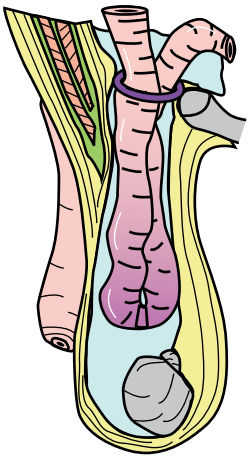


A FEMORAL hernia lies inferior to the inguinal ligament and an INGUINAL hernia superior to it.

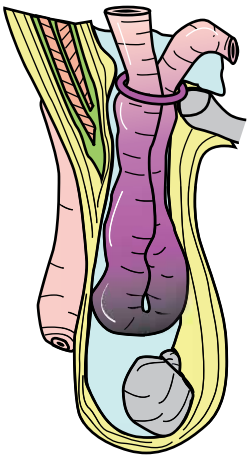
STRANGULATED BOWEL IN A HERNIA



No strangulation (healthy bowel, still reducible)



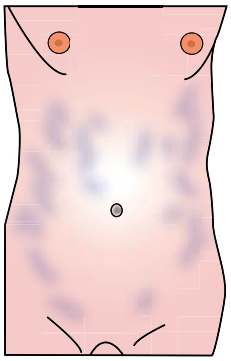
Early strangulation (first venous and lymphatic obstuction then becomes irreducible)



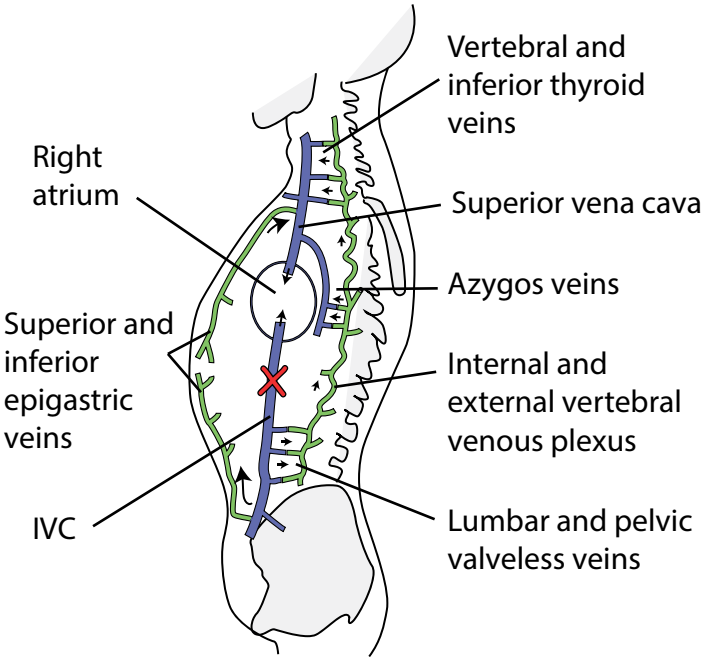
Strangulation with gangrene (arterial obstruction and bowel necrosis)

ORDER OF OBSTRUCTION → Veins → Lymphatics → Leaking tissues → Arteries

ALTERNATIVE VENOUS DRAINAGE WHEN THE INFERIOR VENA CAVA IS BLOCKED

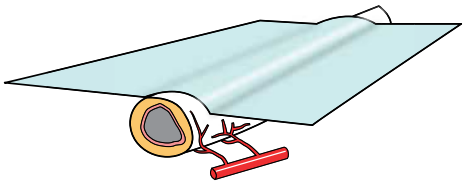


When the IVC is blocked there are two main alternative pathways for the return of blood to the heart. Via the epigastric veins, giving diffuse venous dilatation on the abdominal wall, or via the vertebral plexuses of **valveless** veins



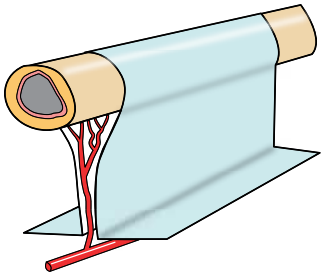
4.2 Peritoneum, Vessels and Nerves

RETROPERITONEAL



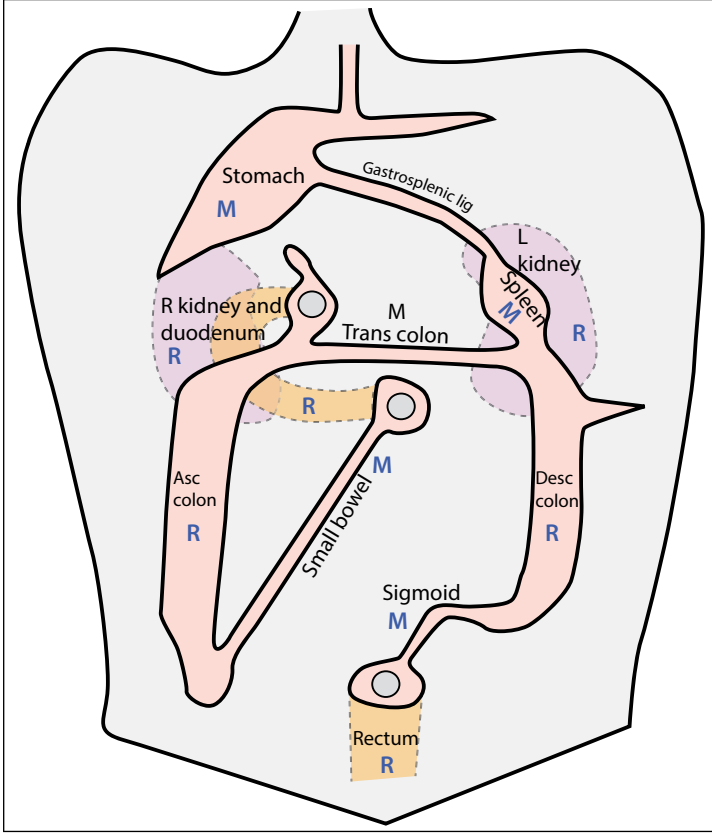
- Most of duodenum
- Ascending colon
- Descending colon
- Rectum
- Pancreas
- Kidneys

ON A MESENTERY



- Stomach
- 1st half of 1st part of duodenum
- 2nd half of 4th part of duodenum
- All small bowel
- Caecum (size dependent)
- Appendix
- Transverse colon
- Sigmoid colon

The only items that are intraperitoneal are: A small amount of peritoneal fluid, the surface of the ovary and the end of the Fallopian tube. All other organs are intra-abdominal but not intraperitoneal



MESENTERY

All the intestines have been removed as far posterior as possible leaving the cut edges of the peritoneum. If the area of denuded peritoneum is narrow then the piece of bowel is on a mesentery. If it is wide then it was retroperitoneal, the exception being the stomach

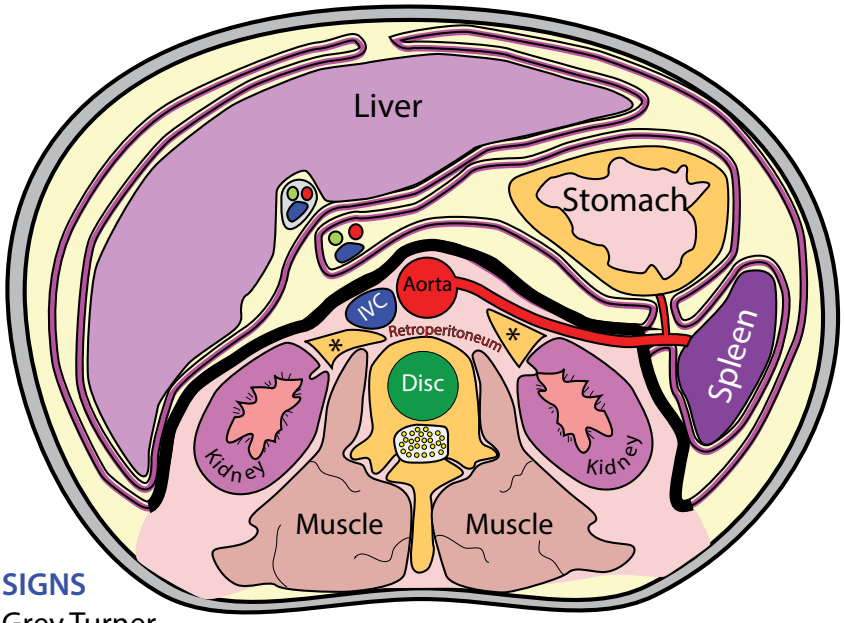
M = On a mesentery

R = Retroperitoneal

RETROPERITONEUM

ORGANS
Adrenals(*)
Kidneys
Ureters
Aorta and branches
IVC and branches
Rectum
Lumbar plexus
Duodenum
Pancreas

DISEASES
Pancreatitis
Trauma
Aneurysms
Iatrogenic

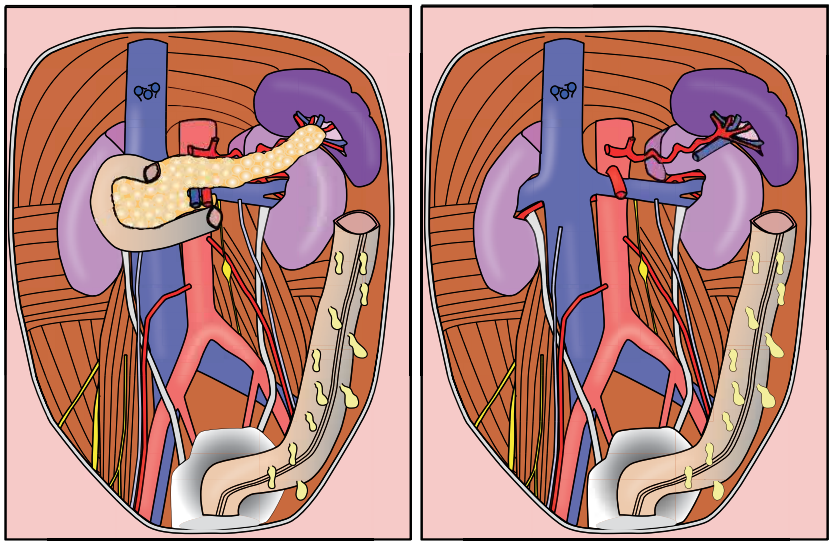


OTHER STRUCTURES
Muscles
Diaphragm
Nerves

SIGNS
Grey Turner
(Flank bruising in retroperitoneal bleeding)

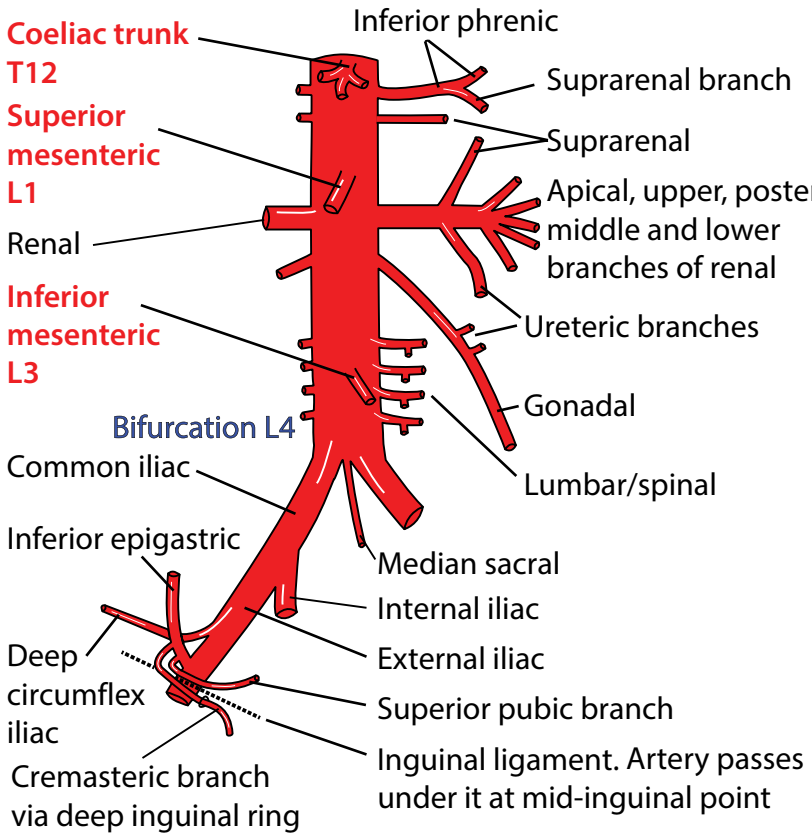
Note: Right adrenal lies partially posterior to IVC

RETROPERITONEUM



Pancreas present | Pancreas removed

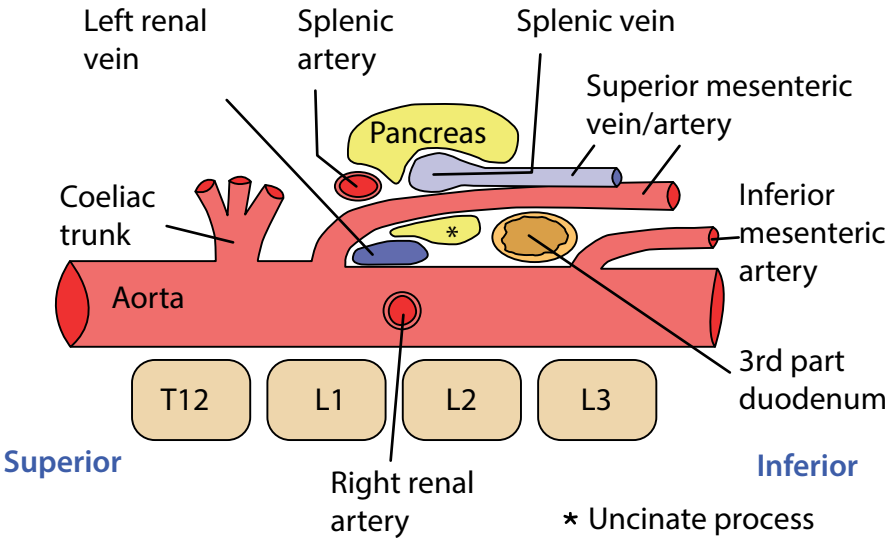
ABDOMINAL AORTA AND RIGHT EXTERNAL ILIAC ARTERY



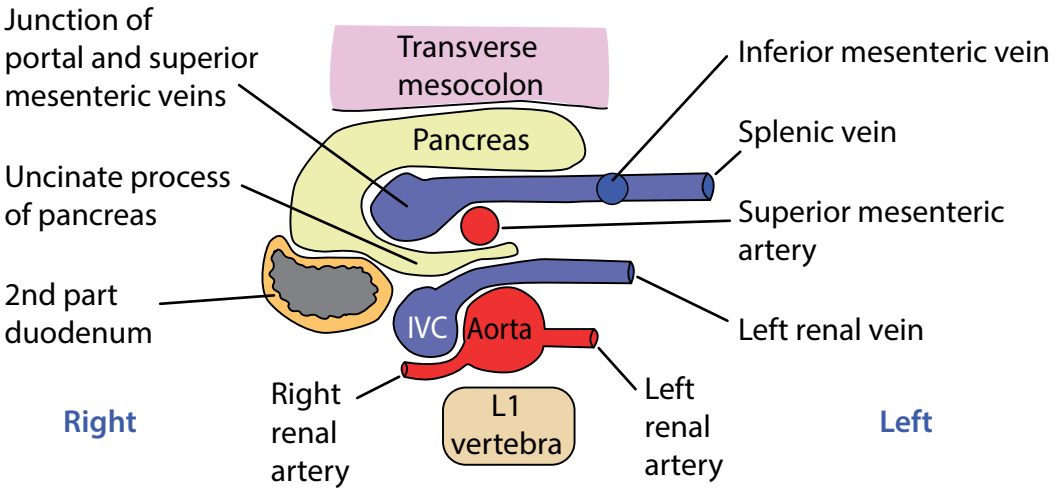
Relations of aorta

Left lateral: Sympathetic chain
Right lateral: IVC, cisterna chyli
Both lateral: Azygos veins, para-aortic lymph nodes, coeliac ganglia
Anterior: Pancreas, splenic vein, left renal vein, 3rd part duodenum, mesentery, lymph nodes, autonomic plexus, lesser sac, stomach, omentum, small bowel
Posterior: T12-L4 vertebrae, left lumbar veins

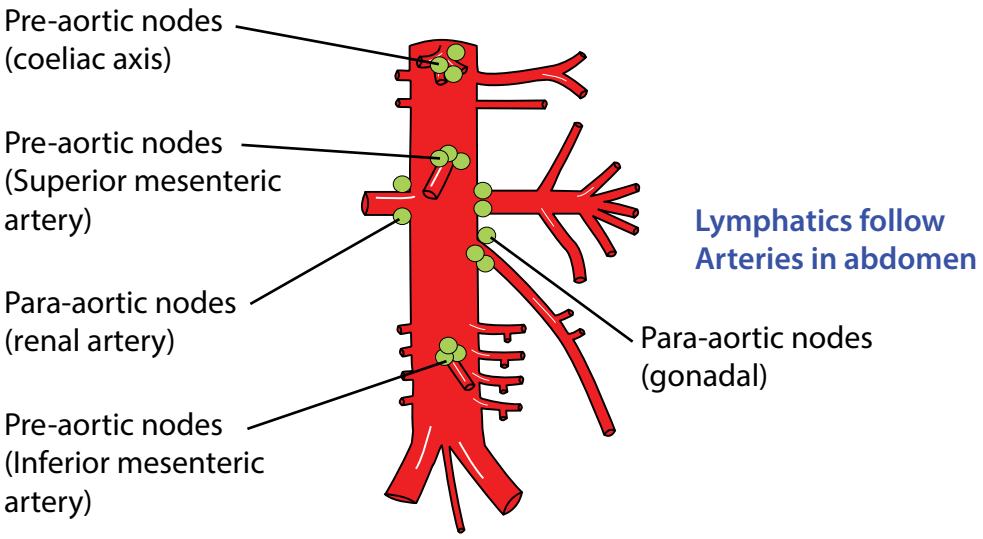
LONGITUDINAL SECTION VIEWED FROM RIGHT



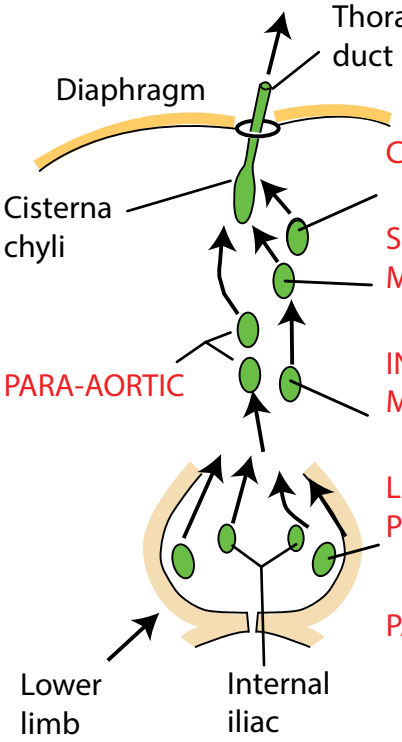
AXIAL (CROSS) SECTION AT L1 LOOKING UP



LYMPHATIC DRAINAGE IN ABDOMEN



ABDOMINOPELVIC LYMPHATICS



COELIAC
- Oesophagus - lower third
- Stomach, greater omentum
- Duodenum - first half
- Spleen, pancreas, liver gall bladder

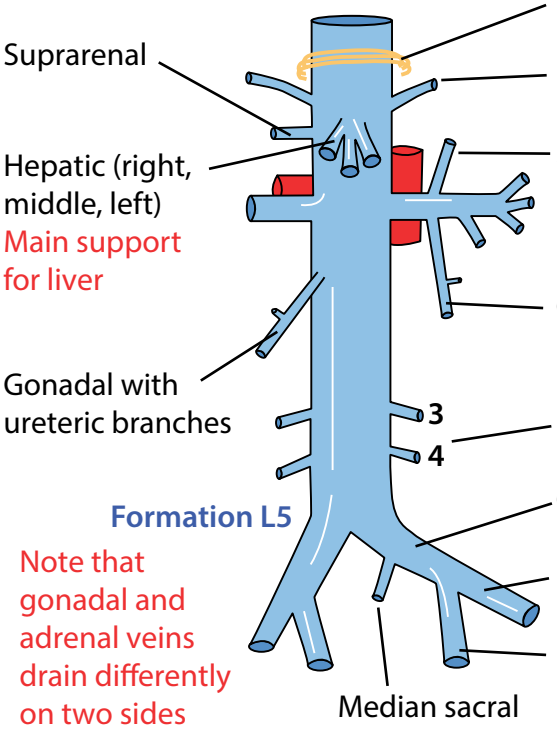
SUPERIOR MESENTERIC
- Duodenum - second half
- Jejunum, ileum
- Caecum and appendix
- Ascending/transverse colon

INFERIOR MESENTERIC
- Distal transverse colon
- Descending/sigmoid colon
- Upper rectum to dentate line

LATERAL PELVIC
- Lower rectum, bladder, urethra, ureter
- Uterus, cervix, upper vagina, clitoris, labia minora, vas, seminal vesicles, prostate, bulk of penis

PARA-AORTIC
- Inferior diaphragm, bare area of liver
- Suprarenal glands, kidneys and ureters
- Gonads (+ tube in female)
- Superior/lateral uterus, Post abdominal wall

INFERIOR VENA CAVA



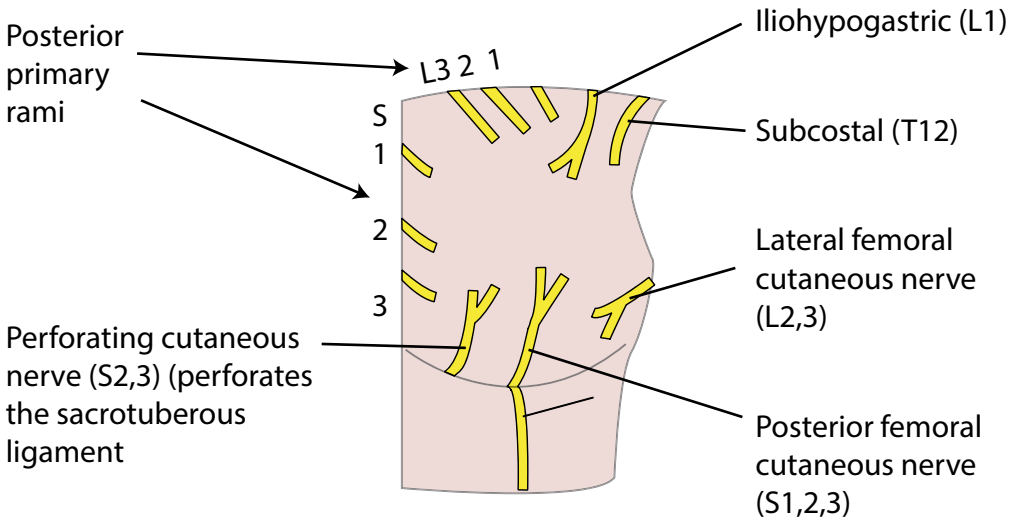
Relations of IVC

Anterior: Bile duct, liver, opening of lesser sac,1st/3rd parts of duodenum, head of pancreas, small bowel, right common iliac artery, root of mesentery, right gonadal artery, portal vein

Posterior: Right renal artery, lumbar arteries, right crus of diaphragm, right suprarenal and its artery, bodies of L3,4,5 vertebrae, right psoas, right sympathetic chain, right coeliac ganglion

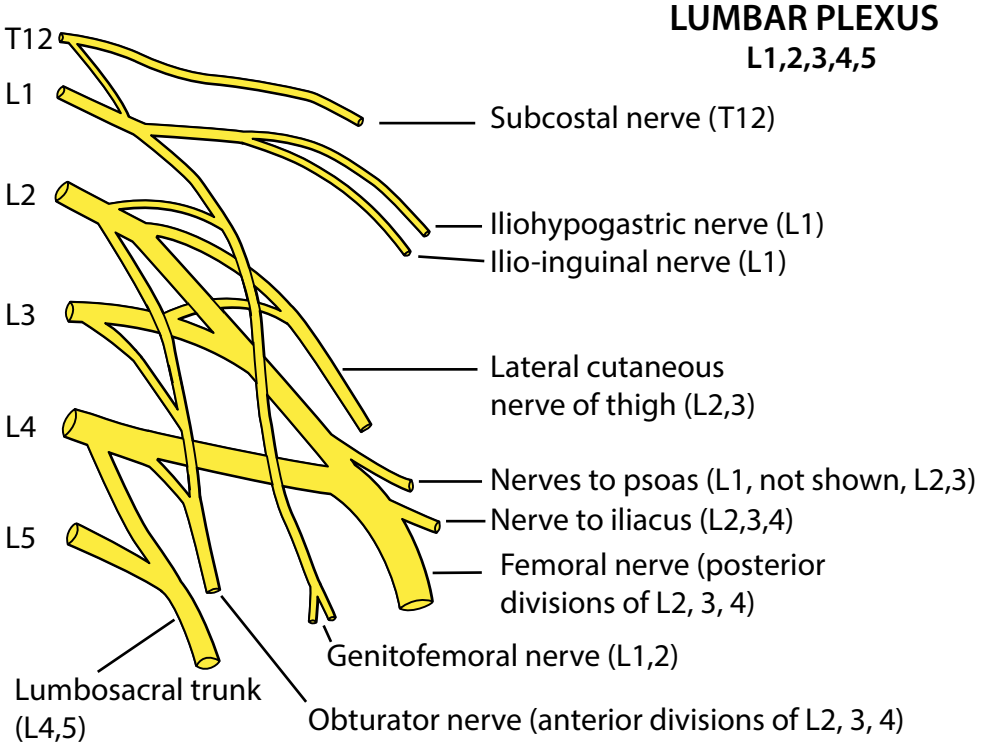
Note: NO tributaries from gut

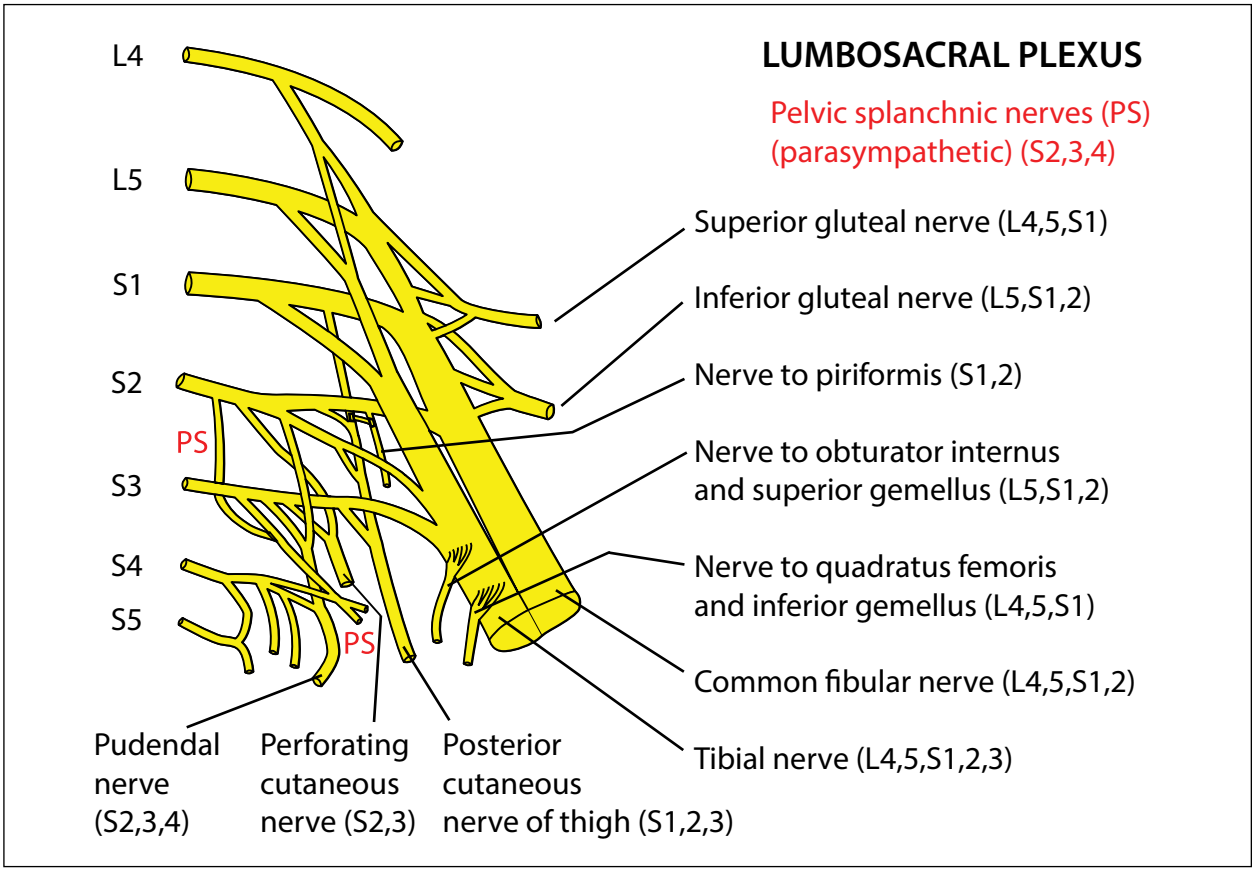
CUTANEOUS NERVE SUPPLY OF BUTTOCKS

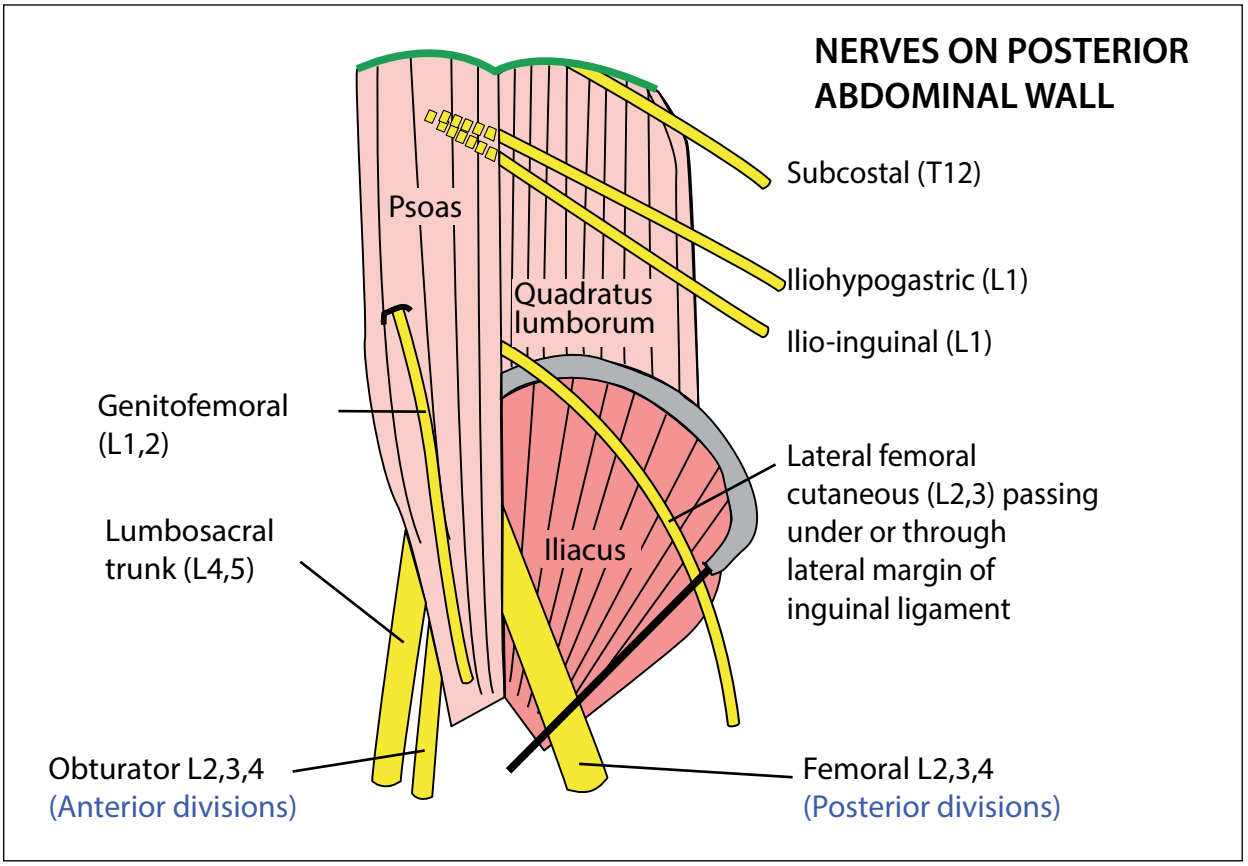


Note that the **POSTERIOR RAMI** of C1, L4,5, S4,5 and the coccygeal nerves do not reach the skin

LUMBAR PLEXUS
L1,2,3,4,5



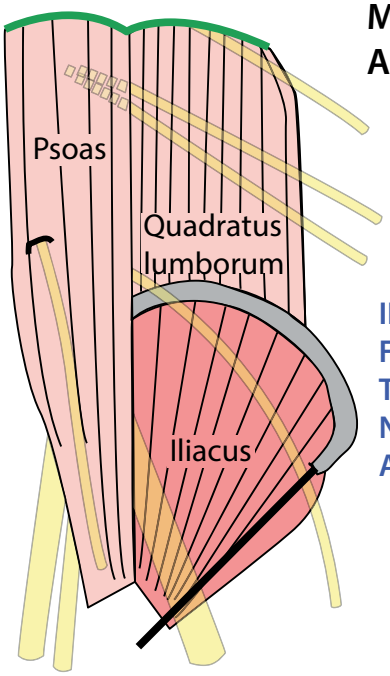

LUMBOSACRAL PLEXUS
L4
L5
S1
S2
PS
S3
S4
S5
PS
Pelvic splanchnic nerves (PS) (parasympathetic) (S2,3,4)
Superior gluteal nerve (L4,5,S1)
Inferior gluteal nerve (L5,S1,2)
Nerve to piriformis (S1,2)
Nerve to obturator internus and superior gemellus (L5,S1,2)
Nerve to quadratus femoris and inferior gemellus (L4,5,S1)
Common fibular nerve (L4,5,S1,2)
Tibial nerve (L4,5,S1,2,3)
Pudendal nerve (S2,3,4)
Perforating cutaneous nerve (S2,3)
Posterior cutaneous nerve of thigh (S1,2,3)


NERVES ON POSTERIOR ABDOMINAL WALL
Psoas
Quadratus lumborum
Iliacus
Subcostal (T12)
Iliohypogastric (L1)
Ilio-inguinal (L1)
Genitofemoral (L1,2)
Lateral femoral cutaneous (L2,3) passing under or through lateral margin of inguinal ligament
Lumbosacral trunk (L4,5)
Obturator L2,3,4 (Anterior divisions)
Femoral L2,3,4 (Posterior divisions)

MUSCLES IN POSTERIOR ABDOMINAL WALL

PSOAS
From: L1-5 transverse processes and discs
To: Lesser trochanter of femur
Nerve: L1,2 segmentally
Action: Flexes hip

QUADRATUS LUMBORUM
From: 12th rib.
To: Transverse processes L1-4 and posterior 1/3 iliac crest
Nerve: T12-L3
Action: Fixes 12th rib

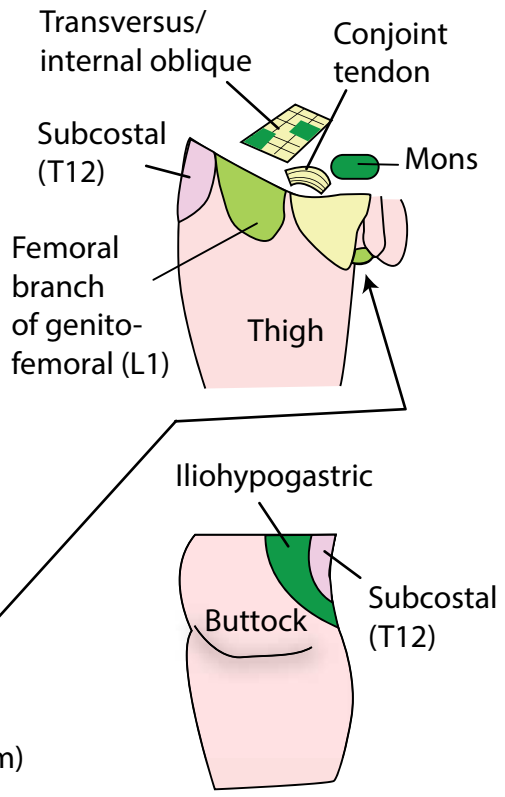


ILIACUS
From: Iliac fossa
To: Lesser trochanter of femur
Nerve: Femoral in abdomen
Action: Flexes hip

ILIOHYPOGASTRIC, ILIO-INGUINAL AND GENITOFEMORAL NERVES

ILIOINGUINAL NERVE
Muscular collateral branch of L1
Motor and sensory
Pierces: Internal oblique above anterior superior iliac spine
Supplies: Lowest fibres of transversus and internal oblique and conjoint tendon. Then enters inguinal canal from above/lateral and leaves via superficial inguinal ring
Supplies: Upper medial thigh, anterior 1/3 scrotum, labia majora and root of penis

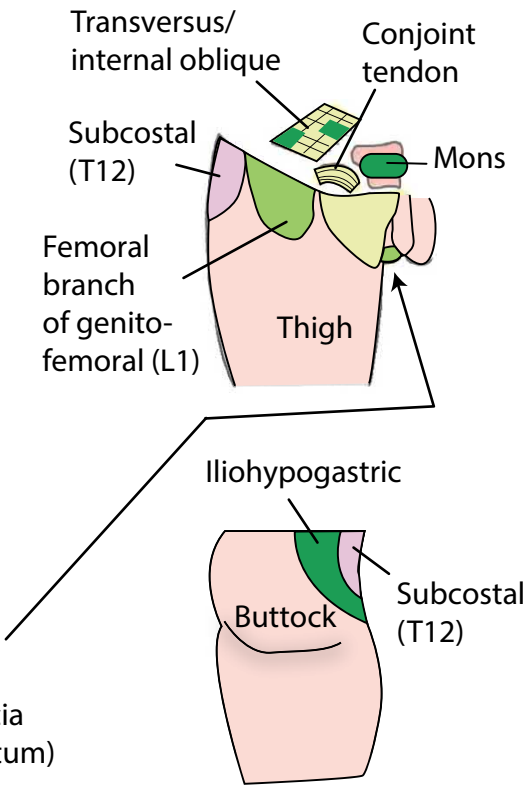
GENITAL BRANCH OF GENITOFEMORAL (L2)
Supplies cremaster muscle, all spermatic fascia and tunica vaginalis, (+/- a small area of scrotum)



ILIOHYPOGASTRIC, ILIO-INGUINAL AND GENITOFEMORAL NERVES

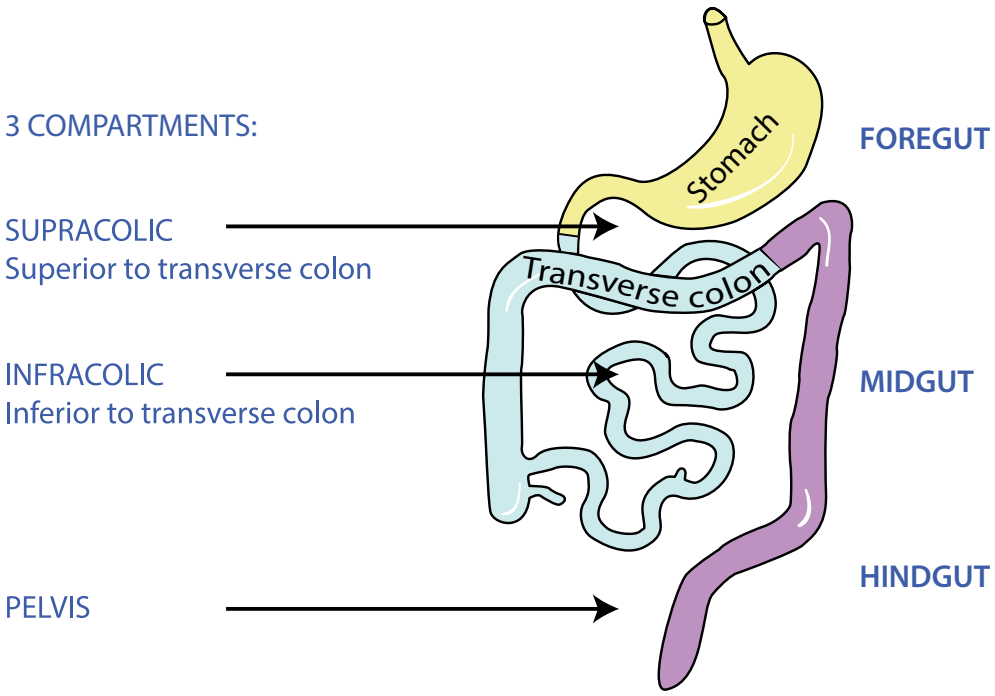
ILIOHYPOGASTRIC NERVE
Main branch of L1
Sensory and motor
Pierces: Internal oblique above anterior superior iliac spine
Pierces: External oblique above superficial inguinal ring
Supplies: Upper buttock (lateral cutaneous branch); Lowest fibres of transversus and internal oblique; skin of mons pubis

GENITAL BRANCH OF GENITOFEMORAL (L2)
Supplies cremaster muscle, all spermatic fascia and tunica vaginalis, (+/- a small area of scrotum)

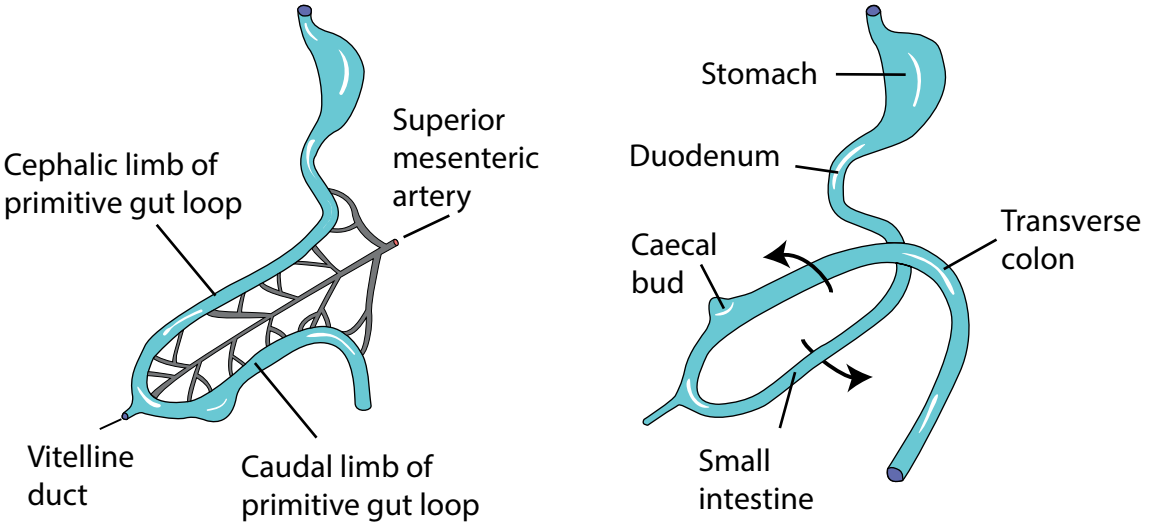


4.3 General Bowel Anatomy and Foregut

COMPARTMENTS OF ABDOMINAL CAVITY

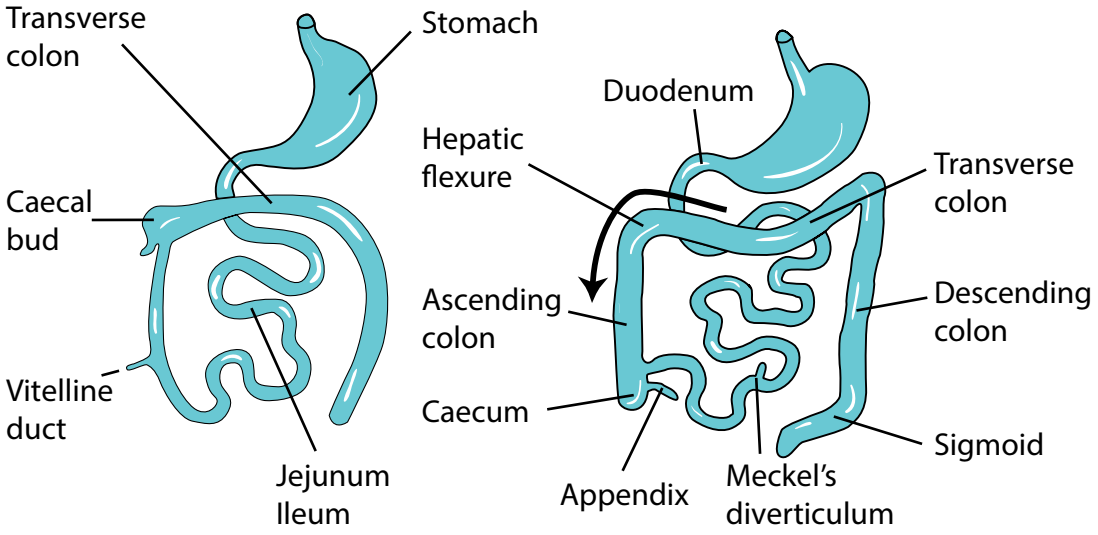


PRIMITIVE INTESTINAL LOOP BEFORE AND AFTER FIRST ROTATION AND DURING PHYSIOLOGICAL HERNIATION BETWEEN 6TH AND 12TH WEEK



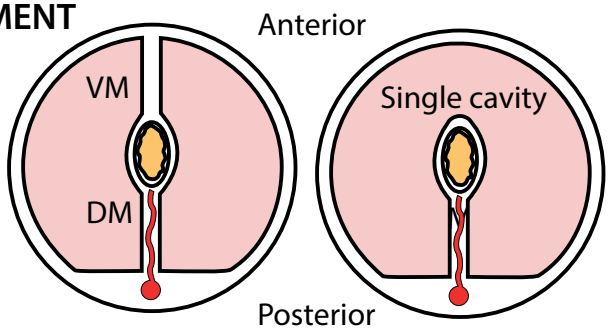
Note: Caecum ends in right hypochondrium after this first rotation

DEVELOPING INTESTINE BEFORE AND AFTER SECOND ROTATION

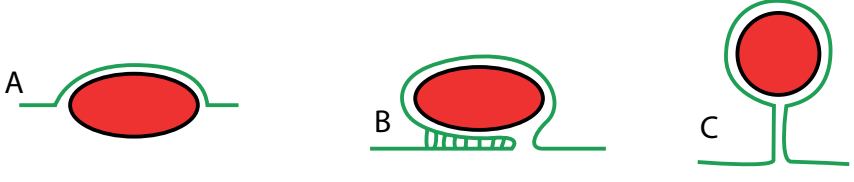


Note: Caecum descends into right iliac fossa after this second rotation

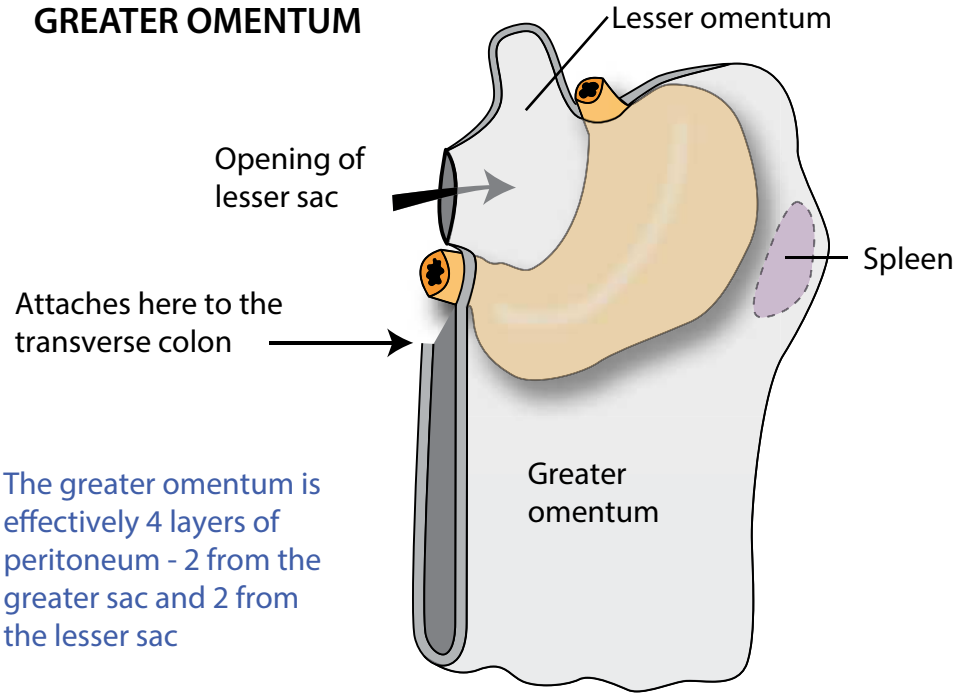
PRINCIPLES OF MESENTERY DEVELOPMENT



1. At the level of the developing foregut which includes the stomach there are two peritoneal cavities separated by a dorsal and ventral mesentery. The stomach is covered by, and suspended between the two. Note access for blood supply in the dorsal mesentery.
2. There is no ventral mesentery below the foregut and thus the primitive bowel is surrounded by dorsal mesentery only.
3. This dorsal mesentery can do one of three things. It can regress posteriorly so that the bowel is then retroperitoneal (A), (e.g. majority of duodenum). Or the bowel can fall on its side and the mesentery is absorbed (B), such as ascending and descending colons. This can be called a pseudo-mesentery. The third alternative is that the mesentery persists (C), such as with the small bowel, and this is described as being "on a mesentery". The length of the mesentery varies throughout the intestine.

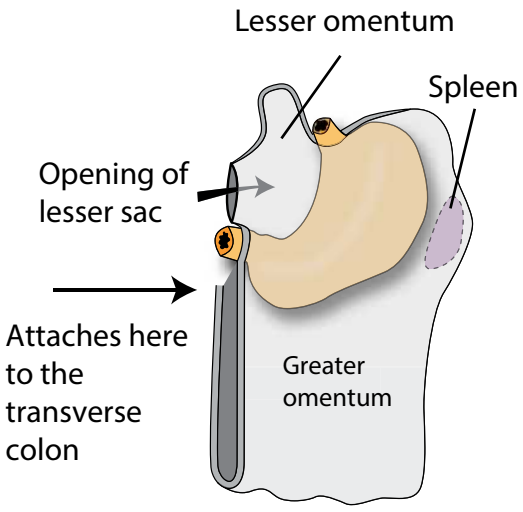


GREATER OMENTUM



The greater omentum is effectively 4 layers of peritoneum - 2 from the greater sac and 2 from the lesser sac

GREATER OMENTUM



The greater omentum is effectively 4 layers of peritoneum - 2 from the greater sac and 2 from the lesser sac

The lesser sac (omental bursa) is an unpaired diverticulum from the general peritoneal cavity that lies posterior to the stomach and lesser omentum. It is accessed via the foramen of Winslow. It is lined by peritoneum that was invaginated from the right side of the stomach as the stomach rotated. It contains nothing apart from a little peritoneal fluid.

Its peritoneum covers:

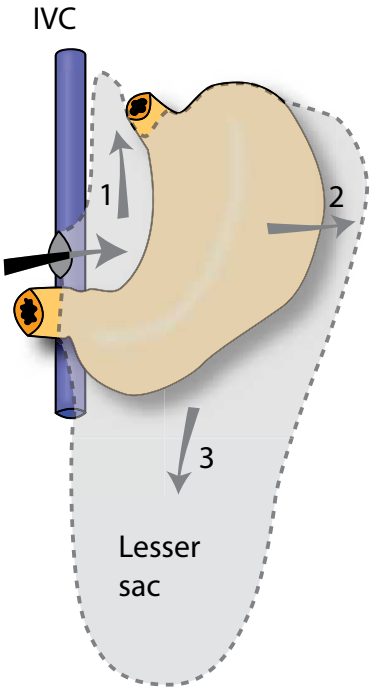
1: Inferior and posterior surface of the liver. 2: Lesser omentum. 3: Body and fundus of stomach and first 2.5cm of duodenum. 4: Inside of greater omentum. 5: Superior aspect of transverse colon 6: Upper body of pancreas. 7: Left adrenal gland. 8: Upper pole of left kidney. 9: Right side of the spleen, gastrosplenic and lienorenal ligaments. 10: Posterior to the floor are: inferior vena cava, aorta, coeliac trunk and its branches. 11: In its free right edge are the portal vein, hepatic artery and bile duct.

LESSER SAC

The arrows indicate the direction of expansion of the lesser sac:

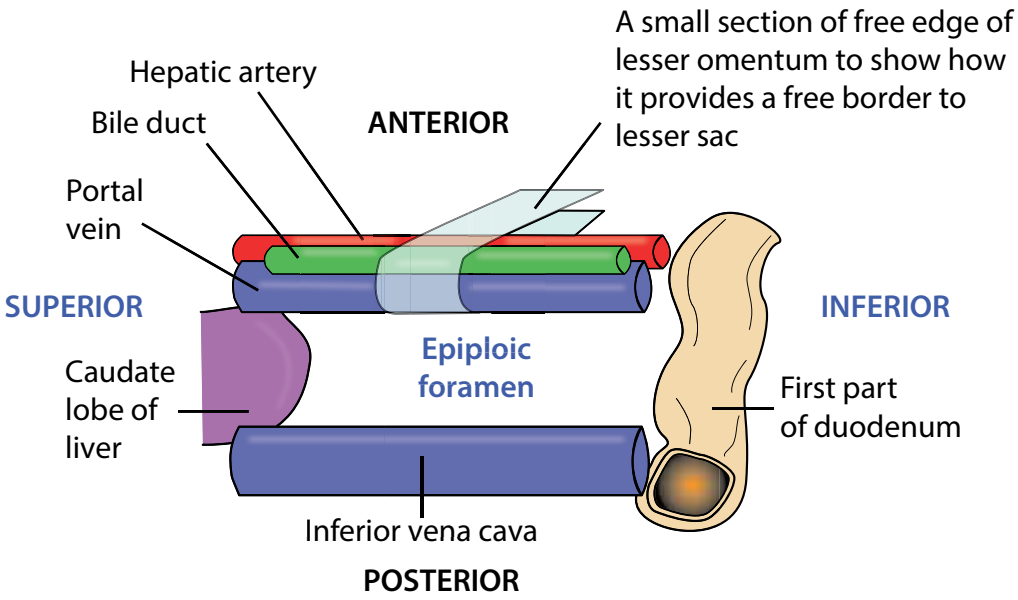
1. Up under the left lobe of the liver
2. Across to the spleen on the left
3. Down within the 2 layers of the greater omentum inferiorly

Note: perforation of posterior wall gastric ulcers can fill the lesser sac with gastric contents



EPIPLOIC FORAMEN

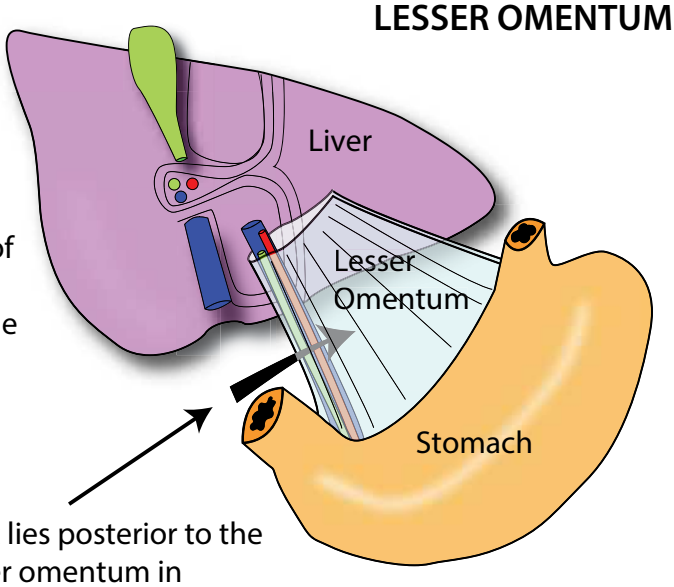
(Foramen of Winslow, Aditus to Lesser Sac)



Simplified diagram looking left into lesser sac from right side of upper abdomen

LESSER OMENTUM

The lesser omentum derives from the ventral mesentery of the stomach and runs between the stomach and the liver. It is the roof (anterior wall) of the lesser sac.

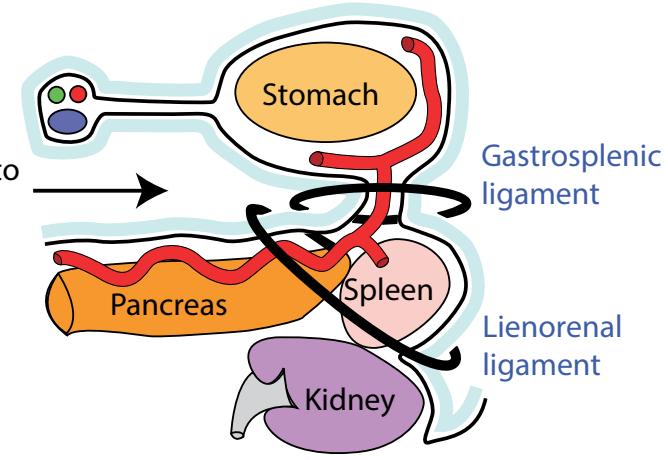


Opening of lesser sac lies posterior to the free edge of the lesser omentum in which lie the portal vein, the bile duct and the hepatic artery

AXIAL SECTION ACROSS FAR LEFT SIDE OF LESSER SAC

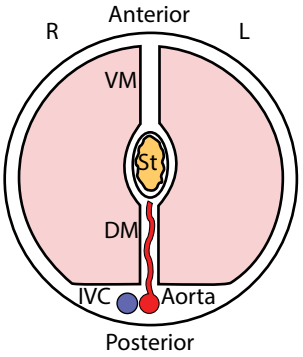
Free edge of lesser omentum

The entrance to the lesser sac



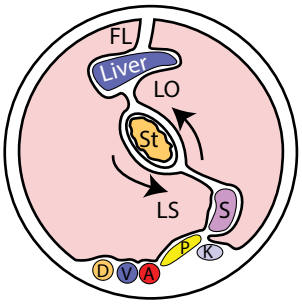
The gastrosplenic ligament contains the short gastric and left gastro-epiploic vessels
The lienorenal ligament contains the tail of pancreas and splenic vessels.

The two ligments are the **remnants of the the DORSAL mesentery** of the stomach. **The ventral mesentery** is the **lesser omentum and the falciform ligament**

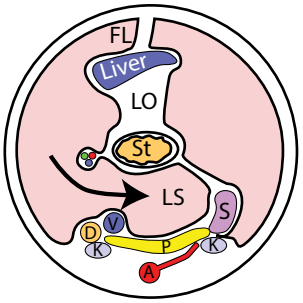


1. Fetus viewed from below. Ventral mesentery (VM) joins the stomach to anterior wall. Dorsal mesentery (DM) joins stomach to posterior wall

ROTATION OF THE STOMACH AND THE FORMATION OF THE LESSER SAC

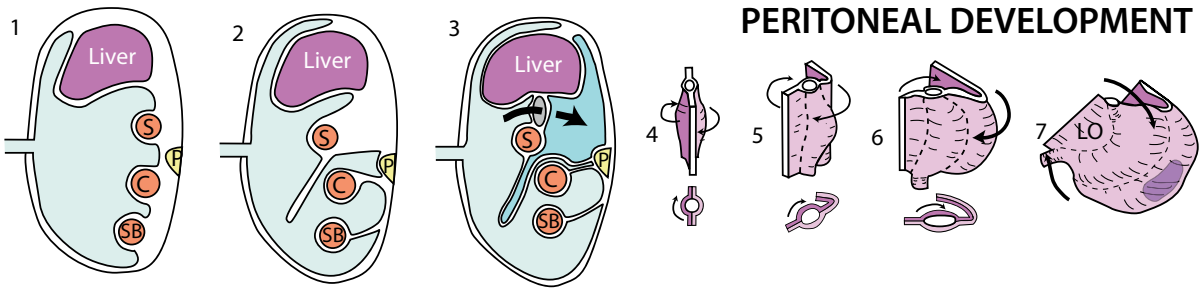


2. The stomach rotates anticlockwise. VM with developing liver in it is thrown to the right and DM with developing spleen in it to the left. Duodenum (D) is pushed retroperitoneally and pancreas (P) is formed posterior to the developing lesser sac (LS) alongside the IVC (V) and the aorta (A). The left kidney (K) lies just posterior to the spleen



3. As the liver enlarges the remnant of the VM between it and the stomach widens to give the lesser omentum (LO) with its free edge holding the bile duct, portal veins and hepatic artery. The anterior remnant of the VM becomes the falciform ligament (FL). The stomach completes its rotation dragging the peritoneum posteriorly to give the lining of the LS. The IVC moves anteriorly to narrow the opening of the lesser sac.

PERITONEAL DEVELOPMENT

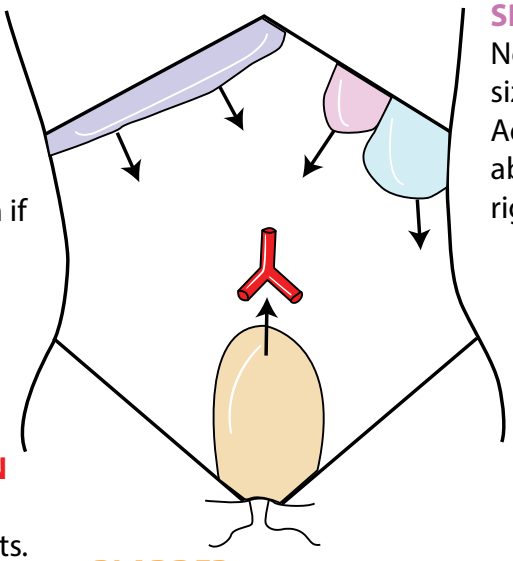


This description is a useful way at looking at peritoneal development but it is NOT the way that it actually happens. Imagine that a large, soft balloon is inserted through the umbilicus and blown up within the abdominal cavity so that it covers all the organs (1,2). It extends around the liver as far as it can but is limited by the attachments of the IVC posteriorly and the bare area. It covers stomach (S), colon (C), small bowel (SB) and pancreas (P).

Between stomach and colon there is a prolapse of peritoneum - the greater omentum. As the SB moves anterior, its peritoneal covering becomes its mesentery. The stomach rotates so that its right side is now facing posteriorly (4 -7). The peritoneum that was on its right side expands posterior to the stomach to become the lesser sac and continues to expand up behind the liver, over the posterior wall of the stomach, onto the superior wall of the transverse colon and half the pancreas. Finally it pushes down between the two layers of the greater omentum to give it four layers. As the stomach also rotates in a coronal plane (7), the opening of the lesser sac (3) becomes a small hole posterior to the lesser omentum (LO) which is called the aditus (opening) of the lesser sac (foramen of Winslow or epiploic foramen).

The LO is the remnant of the ventral mesentery, joining the stomach to the liver (3) which has developed in this mesentery. Note that the spleen develops in the dorsal mesentery of the stomach and thus must finally be in the far left wall of the lesser sac.

PALPABLE ORGANS AND AORTIC BIFURCATION



LIVER
Often just palpable in infancy. In adults it is palpable on inspiration if moderately enlarged

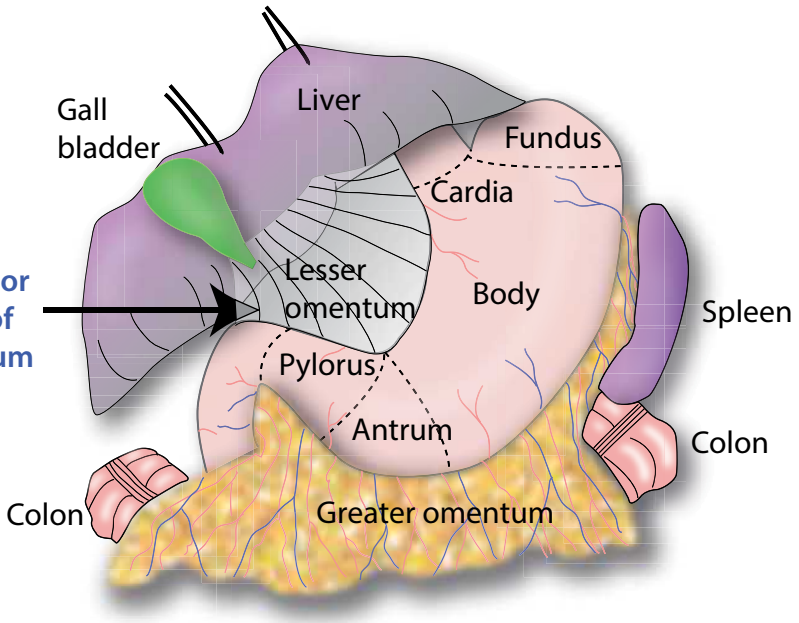
SPLEEN
Needs to be twice normal size to be palpable. Advances down abdomen and across to right

KIDNEY
Bimanually palpable when low lying or moderately enlarged

AORTIC BIFURCATION
Lies at L4. Pulsation is palpable in thin patients. Bruits are listened to at the umbilicus

BLADDER
Lies in abdomen in small children and is fairly easily palpable when full. In adults it sinks into pelvis and is only palpable when very full or chronically distended

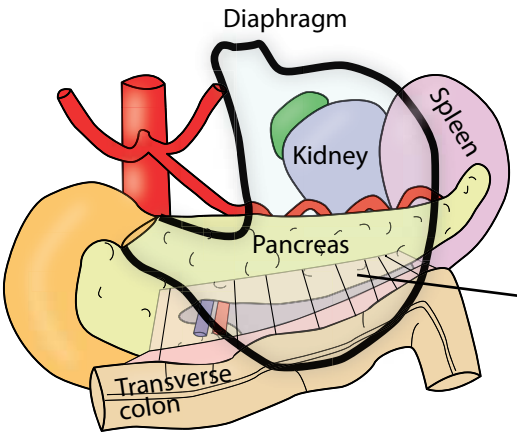
STOMACH AND GREATER OMENTUM



Opening of the lesser sac, posterior to the free edge of the lesser omentum

GREATER OMENTUM: 4 layers of fat filled peritoneum attached along greater curvature of stomach from fundus to duodenum. Lightly attached to transvere colon. "Policeman of abdomen".

RELATIONS OF STOMACH



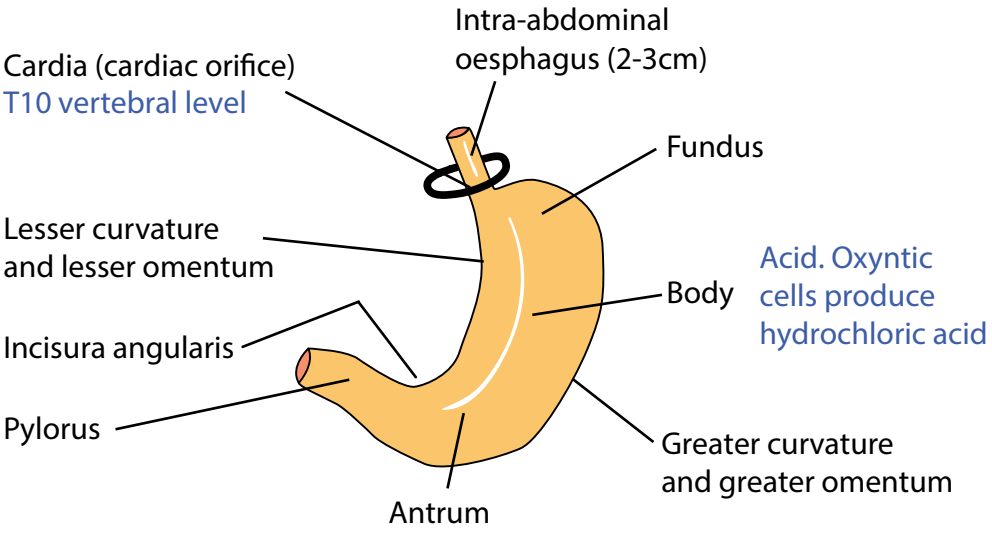
Transverse mesocolon attached along the anterior surface of the pancreas

ANTERIOR
Abdominal wall
Left costal margin
Diaphragm
Left lobe of liver

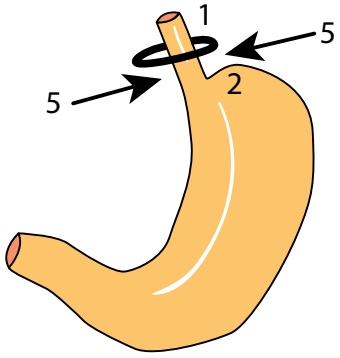
SUPERIOR
Left dome of diaphragm

POSTERIOR
Lesser sac
Pancreas
Transverse mesocolon
Transverse colon
Left kidney/suprarenal gland
Spleen/splenic artery

STOMACH - TOPOGRAPHY AND OESOPHAGOGASTRIC JUNCTION

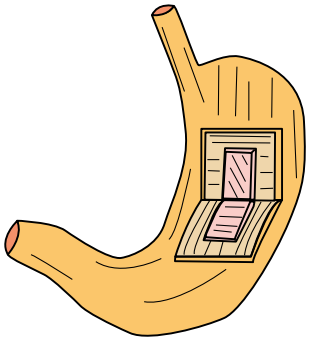


FACTORS PREVENTING GASTRO-OESOPHAGEAL REFLUX



1. Crura. Mostly right but together giving effectively a circle of muscle
2. Angle of oesophagogastric junction
3. Apposition of mucosal folds
4. Phrenico-oesophageal ligament (a fold of connective tissue)
5. Intra-abdominal pressure acting laterally on small section of intra-abdominal oesophagus

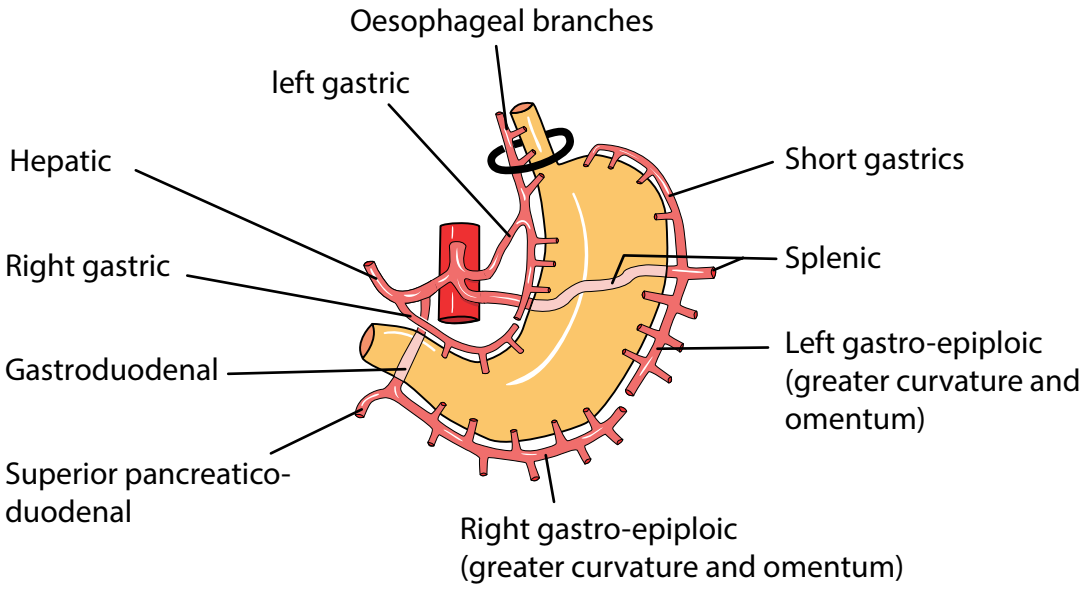
STOMACH - MUSCLE COATS AND CELLS



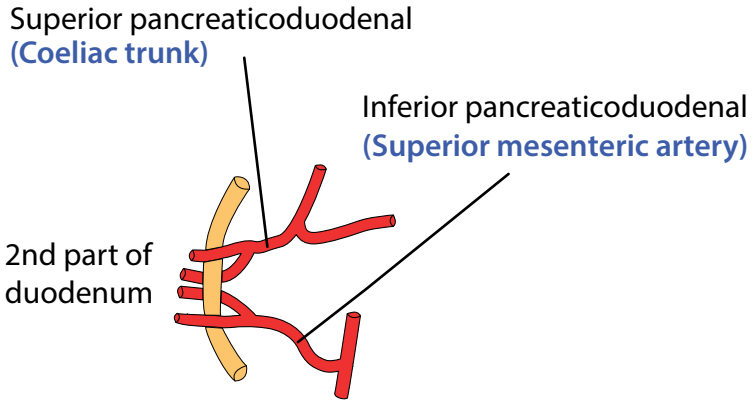
- Outer longitudinal
- Inner circular
- Incomplete oblique innermost
- Mucosal rugae caused by muscle fibres

Note: The following are produced from the cells of the stomach;
Pepsin, hydrochloric acid, gastrin, intrinsic factor, somatostatin, serotonin and endomorphin

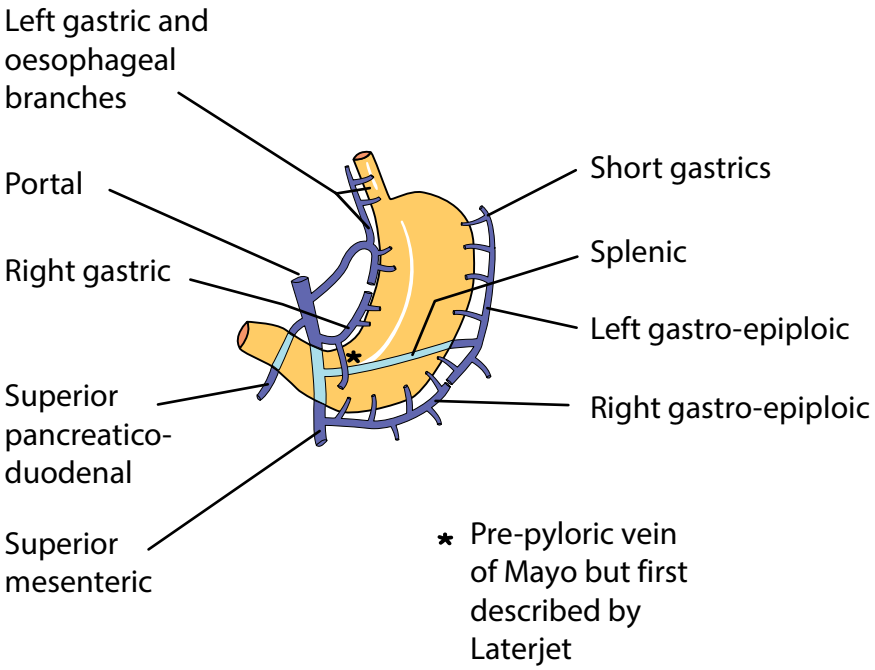
BLOOD SUPPLY OF STOMACH FROM COELIAC AXIS



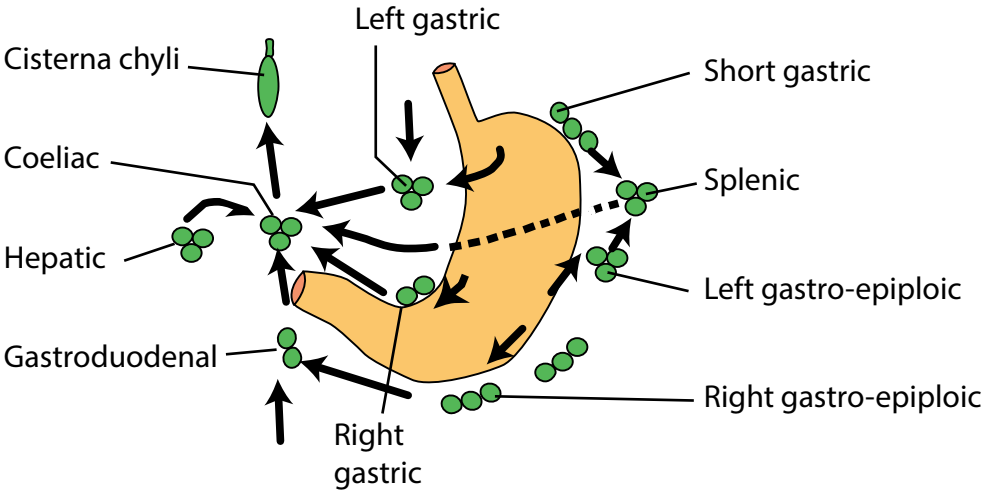
VASCULAR WATERSHED BETWEEN FOREGUT AND MIDGUT



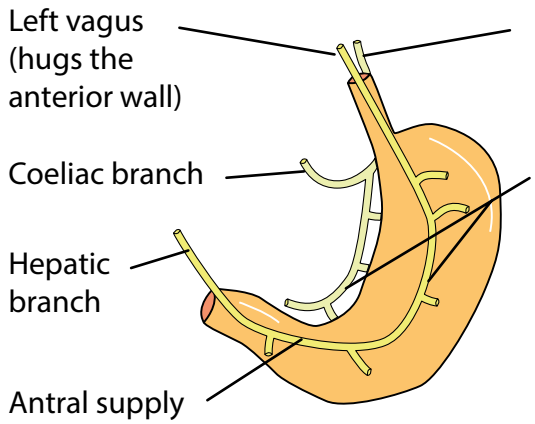
VENOUS DRAINAGE OF STOMACH



STOMACH - LYMPHATIC DRAINAGE



STOMACH NERVE SUPPLY



Referred pain via general visceral afferents in greater splanchnic nerves (visceral sympathetics to T5-9) to epigastrium and lower chest

Vagus nerves are 80% sensory. 20% motor for increasing motility, opening pylorus and initiating secretions

Sympathetics
Greater splanchnic nerves (T5-9) for decreasing motility, vasoconstriction, closing pylorus and sensation

Note: Highly selective vagotomy destroys vagus to fundus and body but preserves nerve to antral pump

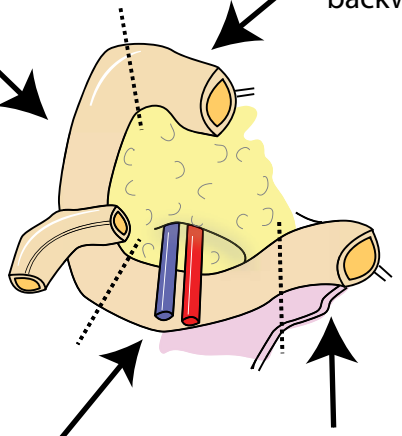
4.4 Midgut and Hindgut

DUODENUM - GENERAL

FIRST PART (2" or 5cm)
- 1st 1/2 with mesentery
- Passes to right, upwards, backwards

SECOND PART (3" or 8cm)
- Retroperitoneal
- On transpyloric plane
- Over hilum of right kidney

Arteries: Superior and inferior pancreatico-duodenal arteries, right gastric artery, right gastro-epiploic artery
Veins: To portal



THIRD PART (4" or 10cm)
- Retroperitoneal
- Superior mesenteric artery and vein pass between body and uncinate process

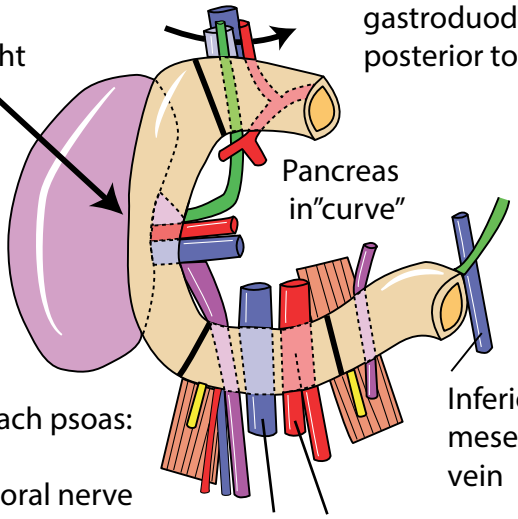
FOURTH PART (1" or 2.5cm)
- Mesentery begins
- Ends as duodenojejunal junction

DUODENUM - MAIN RELATIONS

Arrow in opening of lesser sac

Bile duct, portal vein and gastroduodenal artery posterior to 1st part

Hilum right kidney



Pancreas in"curve"

Referred pain via general visceral afferents in sympathetics to T5-11 (epigastrium and para-umbilical)

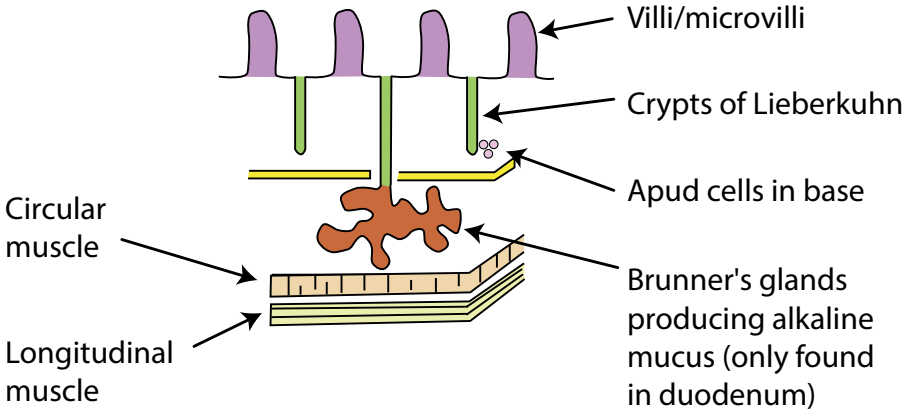
Lying on each psoas:
Ureter
Genitofemoral nerve
Gonadal vessels

Inferior mesenteric vein

IVC

Aorta and inferior mesenteric artery

DUODENUM - HISTOLOGY



Note: Mucosa is thrown into folds called plicae circulares or valvulae conniventes

SMALL BOWEL MESENTERY AND SECRETIONS

ORIGIN OF SMALL BOWEL MESENTERY

- 6 inches (15cm) long
- Starts at the duodenojejunal junction, just to left of L2 vertebra and extends down and to the right to reach the right sacro-iliac joint at S2 sacral level
- Contains superior mesenteric vessels, lymphatics and autonomic nerves

SECRETIONS FROM SMALL BOWEL

- Mucus, lysozyme, secretin, somatostatin, cholecystokinin, serotonin and endomorphin, VIP, GIP, etc

SMALL BOWEL MESENTERY

SMALL BOWEL MESENTERY

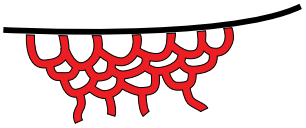
15cm (6") long. Bowel average length 6m (2-10m)
Starts at the duodenojejunal junction, just to left of L2 vertebra and extends down and to the right to right sacro-iliac joint at S2 sacral level.
Contains superior mesenteric vessels, lymphatics and autonomic nerves.

JEJUNUM
2/5, red, wide bore, thick wall

Valvulae conniventes, plicae circulares ++, sparce arcades

ILEUM
3/5, pink, narrow bore, thin wall

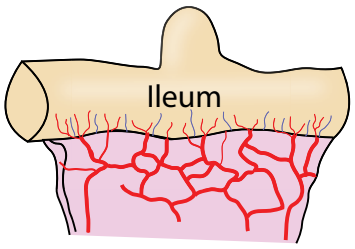
Smooth wall, Peyer's patches, multiple arcades



BLOOD: Ileal and jejunal branches of superior mesenteric artery.
NERVES: General visceral afferents in lesser splanchnics (sympathetic) referred to T10/11 (para-umbilical)

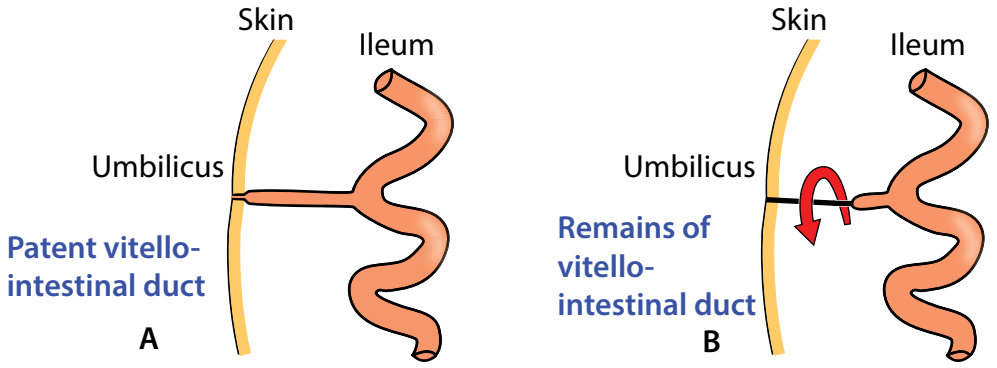
MECKEL'S DIVERTICULUM

- Remnant of the vitello-intestinal duct which normally closes off early in development.
- Approximately: 2-3% of people, 2-3 inches long and 2-3 feet from the ileocaecal valve.
- May contain gastric, pancreatic, liver, carcinoid or lymph tissue.
- May remain attached to umbilicus as persistent vitello-intestinal tract which may leak or cause intestinal obstruction as the bowel wraps around it.
- Symptoms very similar to appendicitis. Erosion by acid producing cells can lead to haemorrhage within the bowel.
- Lies on antimesenteric border of ileum.



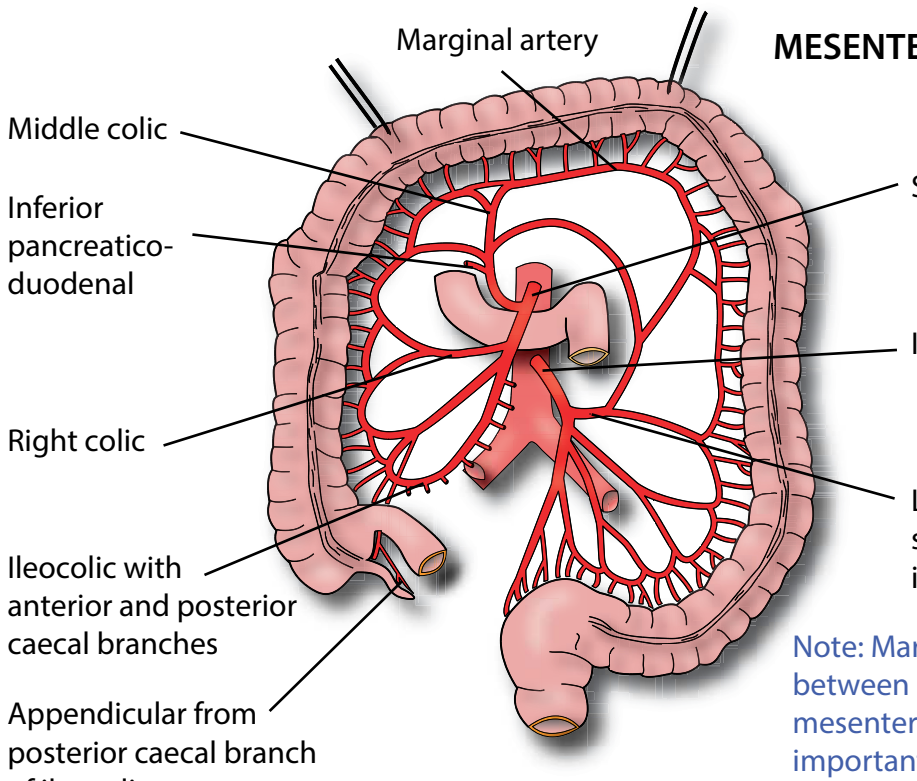
UMBILICUS

Problems associated with Meckel's diverticulum



Meckel's diverticulum is the remnant of the vitello-intestinal duct. It may remain open to give a fistula to the surface at the umbilicus (A) with leakage of intestinal content. Or it can remain as a strand of tissue around which the small bowel can rotate and become obstructed.

MESENTERIC ARTERIES

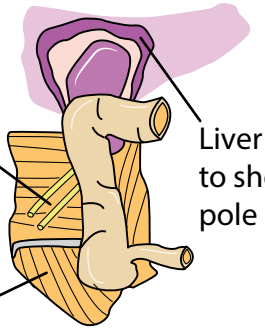


Note: Marginal artery is a link between superior and inferior mesenteric arteries and an important anastomosis 2/3

COLON

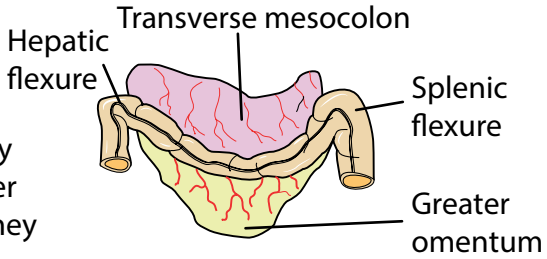
ASCENDING COLON

- 15cm (6")
- Retroperitoneal



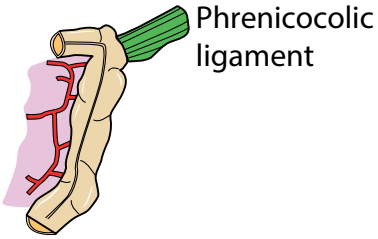
TRANSVERSE COLON

- 45cm (18")
- Fixed at both ends

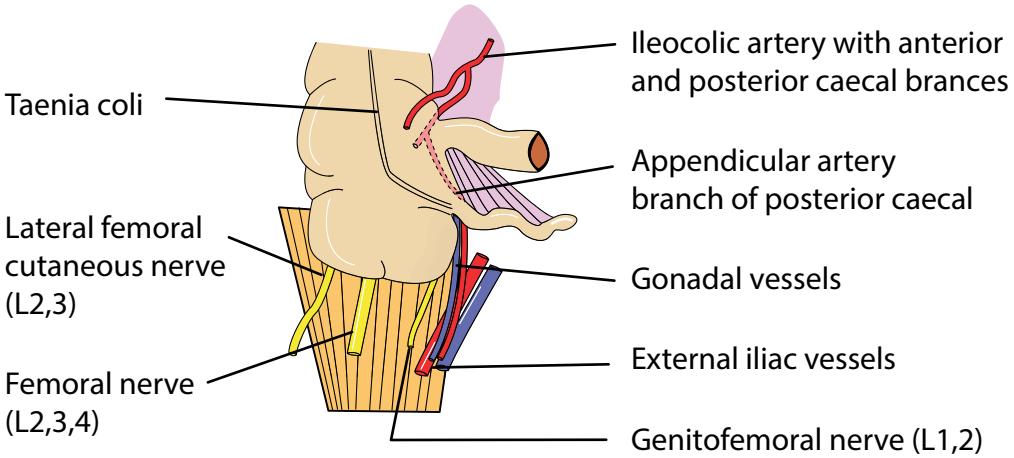


DESCENDING COLON

- 30cm (9-12")
- Retroperitoneal
- Appendices epiploicae ++
- Lies on psoas, iliacus, transversus abdominis, quadratus lumborum



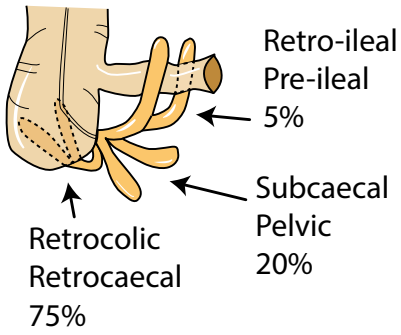
CAECUM AND APPENDIX 1

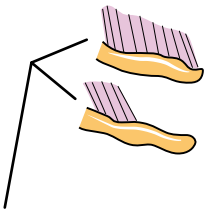


CAECUM

- On mesentery; Below ileocaecal valve
- Retrocaecal fossa behind it
- 3 taenia coli meet at base of appendix
- Ileocaecal valve is a double fold of mucosa and circular muscle of ileum which acts as an anti-reflux mechanism

CAECUM AND APPENDIX 2

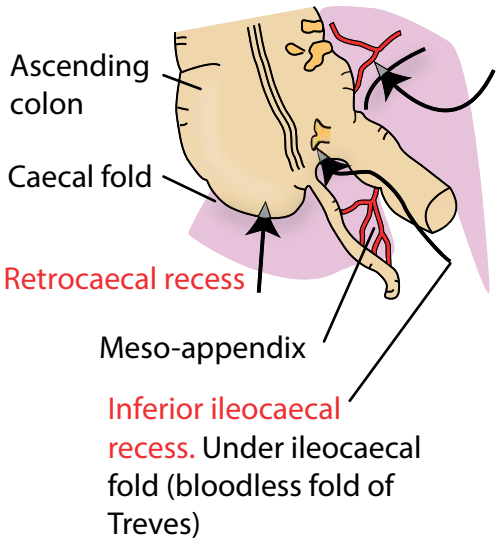




APPENDIX

- At McBurney's point
- 2-25cm (1/2"-9") average 7-8cm
- Fully coated diverticulum
- Appendicular artery usually from posterior caecal artery. It is an end artery hence appendix can easily become gangrenous. Appendix moves posterior and medial with caecal expansion

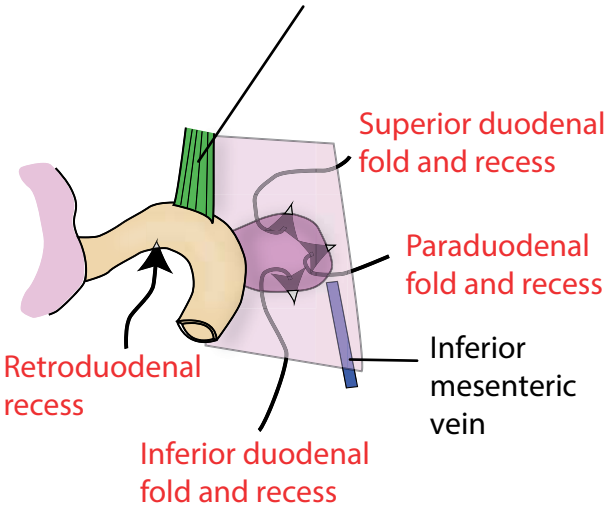
PERITONEAL RECESSES



There are a number of small recesses that are potential areas for internal herniation of bowel or other structures

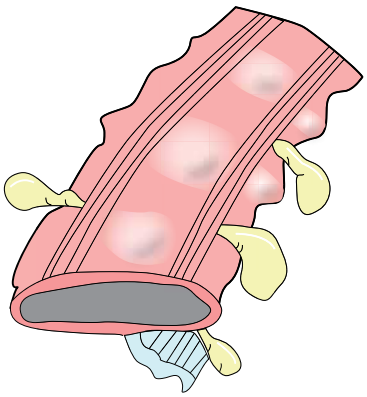
Ligament of Treitz

Thin band of smooth muscle from right crus, passes anterior to aorta/renal vessels but behind pancreas, to blend with outer coat of duodenojejunal flexure



COLON

(Approximately 5 foot -1.4m)



Colon

Appendices epiploicae: Little tags of fat on the mesentery border of the bowel.

Taenia coli: Outer longitudinal muscle in three flat bands. Not in appendix

Sacculations and Haustrations/valvulae conniventes: Due to shortness of taenia coli

Mesentery: Transverse and sigmoid only

THEY ALL STOP BEFORE THE RECTUM BEGINS

Lymphatics: Alongside superior/inferior mesenteric vessels to para-aortics to coeliac and on upwards to thoracic duct.

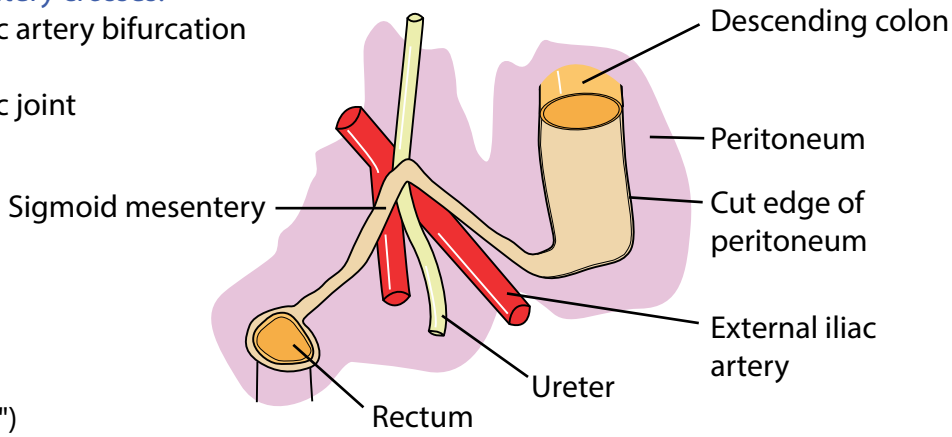
Nerves: Parasympathetic - vagus to 2/3 along transverse colon then S2,3,4 to rest of bowel.

Sympathetics T10-L2 for vasoconstriction and to carry general visceral afferents (GVA's) for pain. For organs of cloacal origin GVAs may be carried in the parasympathetics

SIGMOID COLON

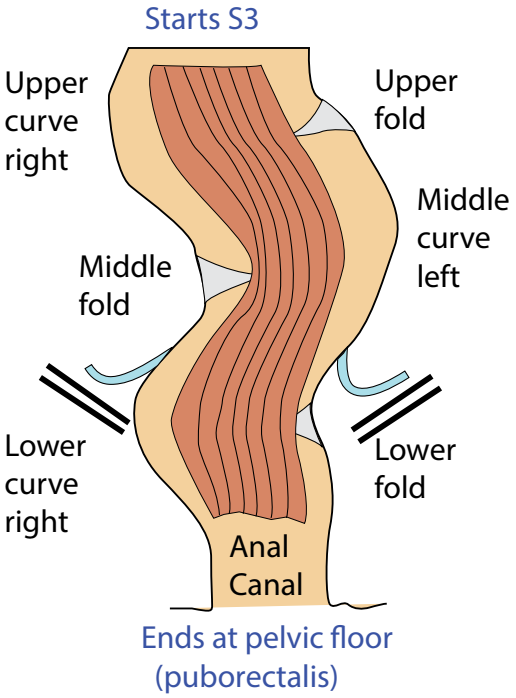
Base of mesentery crosses:

- Common iliac artery bifurcation
- Left ureter
- left sacro-iliac joint



- 5-45cm (5-30")
- From pelvic brim to S3 midline
- On mesentery
- Appendices epiploicae +++
- Taenia become progressively more as a longitudinal coat

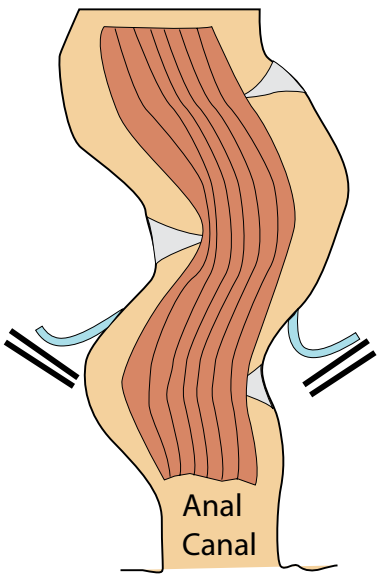
RECTUM
(length and peritoneal covering)



12cm long	Peritoneum
4cm	Covers sides and front
4cm	Covers front only
4cm	Below pelvic floor

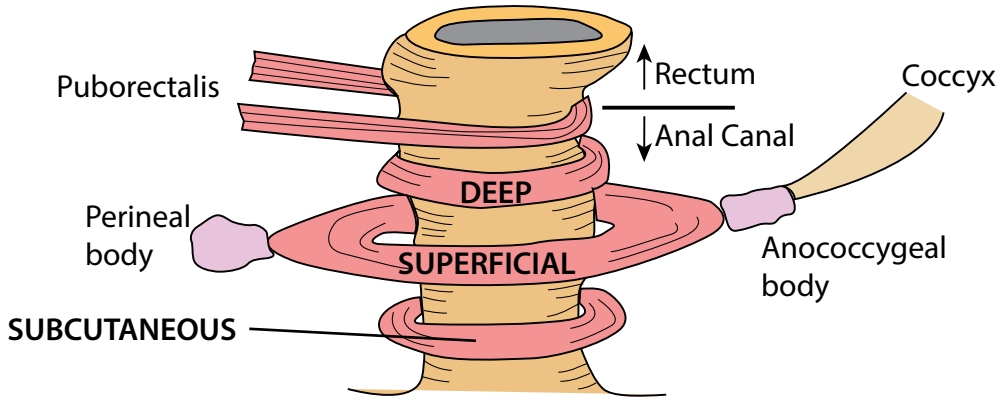
Anterior and posterior wide bands of longitudinal muscle

RECTUM: DETAILS



- No mesentery
- Folds (shelves) are mucosa and circular muscle = valves of Houston
- The rectum is normally empty but fills before and during defaecation
- Upper 2/3 is distensible into abdominal cavity and may store faeces in constipation
- Lower 1/3 can distend laterally into the ischio-anal fossa during defaecation
- Note: longitudinal muscle is two wide bands anteriorly and posteriorly

ANAL SPHINCTERS



CONTINENCE

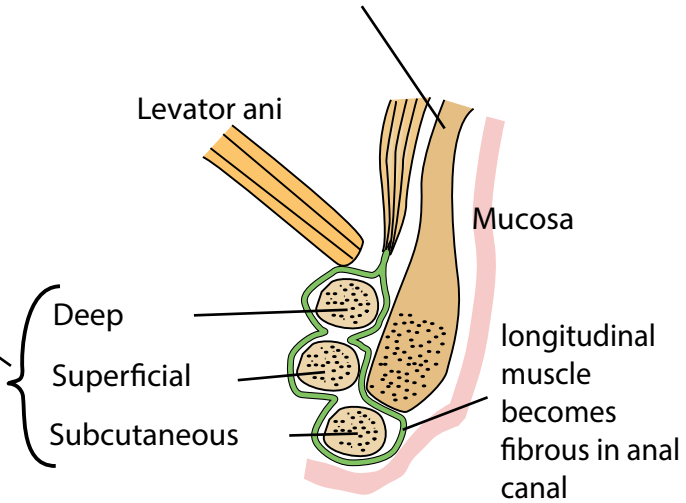
Failure of any of these can lead to incontinence!

- Internal anal sphincter (involuntary)
- External anal sphincter (voluntary)
- Anorectal angle (puborectalis)
- Anal cushions and mucosal folds
- Abdominal pressure on upper, anterior part of lower rectum

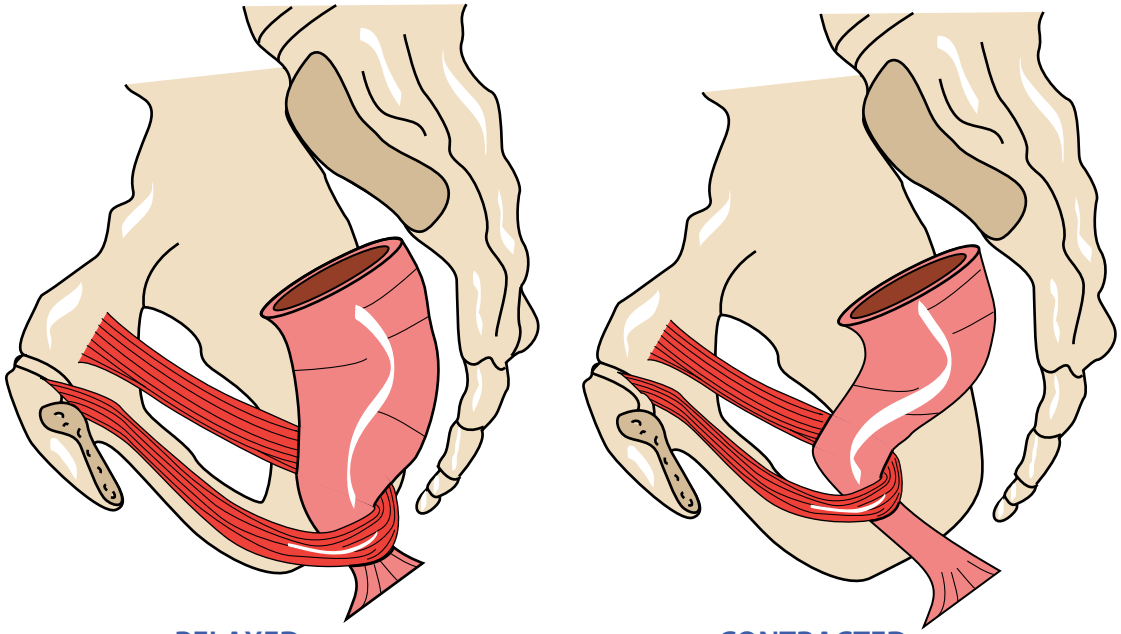
INTERNAL AND EXTERNAL ANAL SPHINCTERS

Circular muscle becomes the **"involuntary internal anal sphincter"** which relaxes with moderate pressure from above

Parts of the **"voluntary external anal sphincter"** that reflexly or voluntary relax with high pressure from above



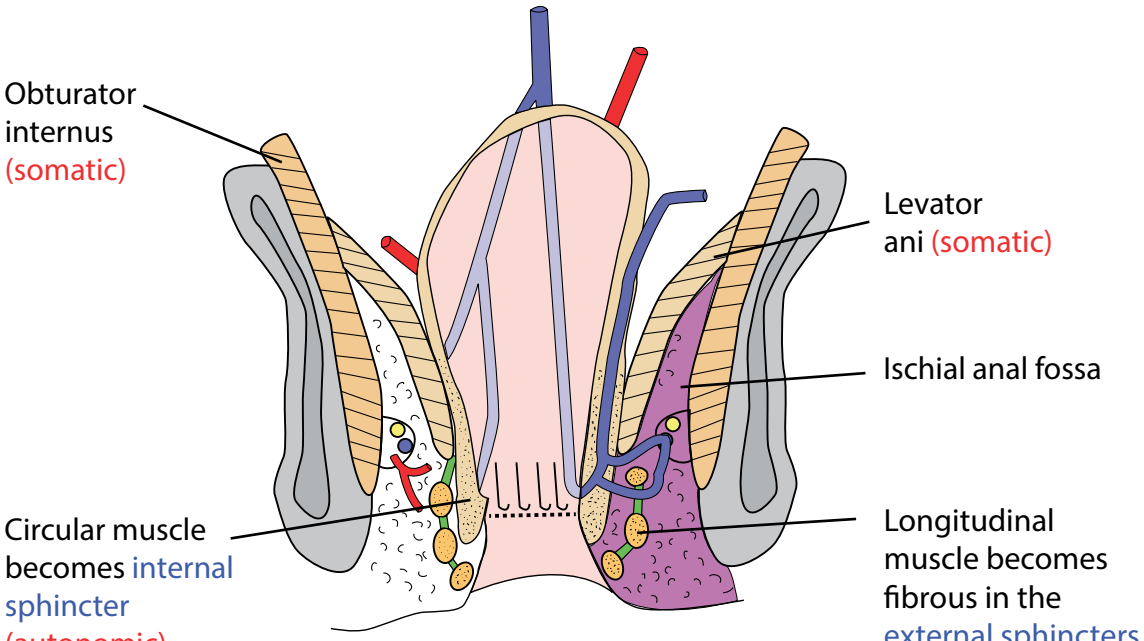
PUBORECTALIS SLING



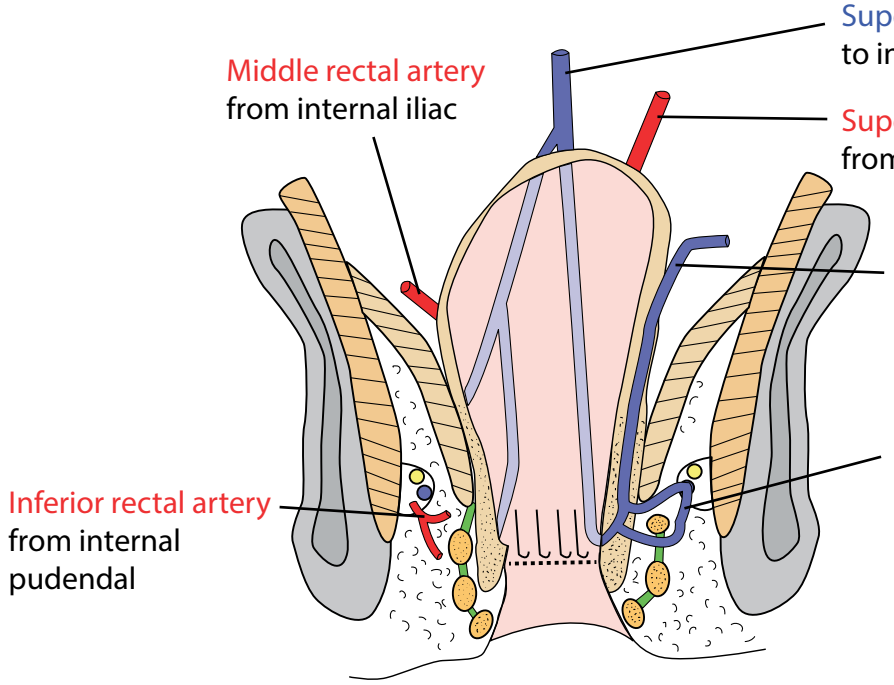
RELAXED
(Rectum almost straight)

CONTRACTED
(Rectum acutely angled)

ISCHIOANAL FOSSA AND RECTAL MUSCLES

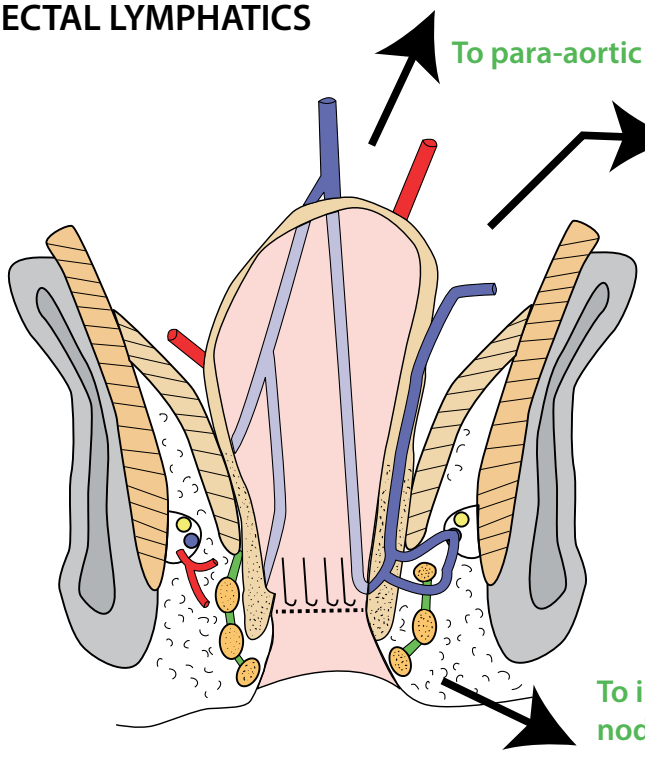


RECTAL BLOOD SUPPLY



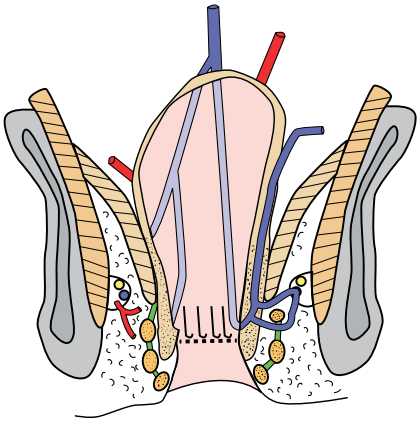
Portosystemic anastomosis in upper anal canal where internal and external venous plexuses meet

RECTAL LYMPHATICS



RULE: Lymphatics from viscera follow deep arteries back to nodes around the origin of the artery

RECTAL NERVE SUPPLY - AUTONOMIC



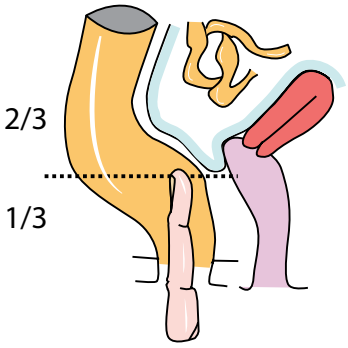
Sympathetic:
Contract smooth muscle sphincters, relax bowel, transmit pain

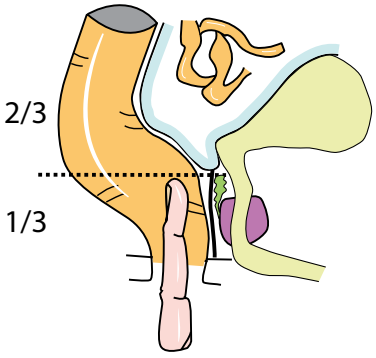
Parasympathetic:
Relax smooth muscle sphincters, contract bowel, transmit fullness

Anocutaneous reflex
Lightly stroking the buttock skin near the anal canal should cause a reflex contraction of the voluntary external anal sphincters

Note: Rectum is capable of distinguishing between AIR, WATER AND FAECES

RELATIONS OF RECTUM





FEMALE - anterior
Recto-uterine pouch (of Douglas), Small bowel, posterior fornix/vagina, uterus and bladder

MALE - anterior
Rectovesical pouch, small bowel, bladder, prostate, vas, seminal vesicles, Denonvillier's fascia (which is probably a double layer of peritoneum acting as a major factor in preventing the spead of cancer in either direction)

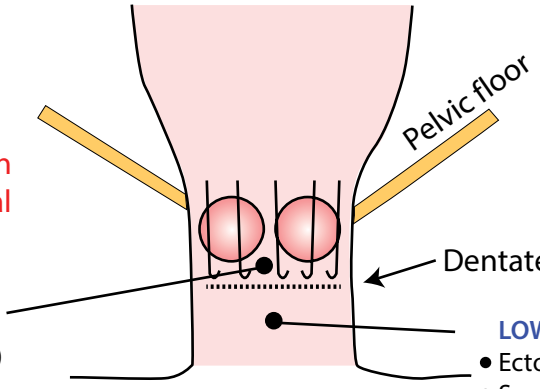
POSTERIOR - both
Fascia, median sacral and rectal vessels, sympathetic trunk, pelvic splanchnic nerves, piriformis, sacral and coccygeal roots, sacrum, coccyx, anococcygeal body

LATERAL - both
Peritoneum, fat, nodes, obturator internus and its fascia, Alcock's canal and contents, levator ani and coccygeus, ischio-anal fossa, lateral (fascial) ligaments of rectum

ANAL CANAL

4cm long. Pelvic floor (puborectalis) to outside

Anocutaneous reflex: Touching the skin near the anus (S2,3,4) gives a reflex contraction of the external anal sphincters

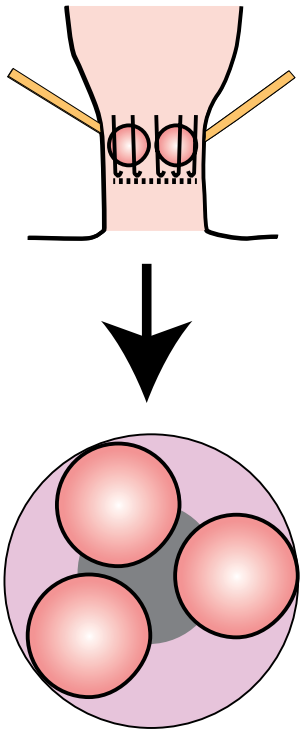


UPPER HALF (2cm)

- Endoderm origin (bowel)
- Columnar mucosa
- 12 columns/valves and 3 cushions
- Autonomic nerves
- Insensitive to touch
- Superior, middle, inferior rectal arteries
- Mixed portal and systemic venous drainage
- Lymphatics to para-aortic lymph nodes
- Potential for adenocarcinoma
- Site of haemorrhoids

LOWER HALF (2cm)

- Ectoderm origin (skin)
- Squamous mucosa
- Somatic nerves
- Sensitive to touch
- Mainly inferior rectal artery
- Systemic venous drainage
- Lymphatics to superficial inguinal nodes
- Potential for squamous carcinoma
- No haemorrhoids



ANAL CANAL - UPPER HALF

3 spongy muscosal cushions are in the upper half, at 3, 7 and 11 o'clock. They contain bright red capillary blood.
They help with continence , air tightness and mucus production.
Enlargement leads to haemorrhoids (piles).

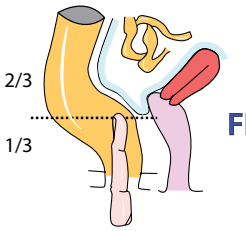
NOTE: Although they are at the same level as the venous plexuses (which can enlarge in a portosystemic anastomosis) they are quite separate from them

INVESTIGATION OF FAECAL INCONTINENCE

Digital anorectal examination, wearing a well lubricated glove

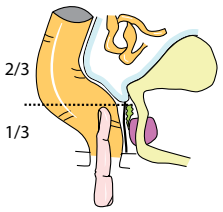
Assess:

- Puborectalis and external sphincters
- Evidence of constipation
- Pressure on rectum from other organs
- Tumours in prostate or rectum



FEMALE

Anterior: Recto-uterine pouch, small bowel, posterior fornix/vagina, uterus



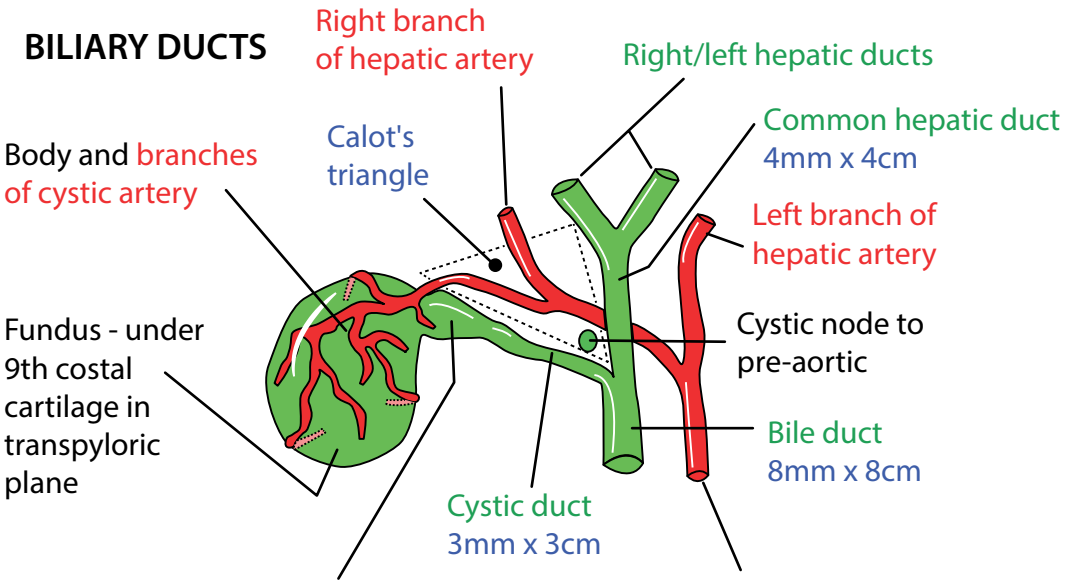
MALE

Anterior: Rectovesical pouch, small bowel, bladder, prostate, vas, seminal vesicles, Denonvillier's fascia

Consider a central prolapsed disc!

4.5 Biliary System, Portal System, Pancreas and Spleen

BILIARY DUCTS

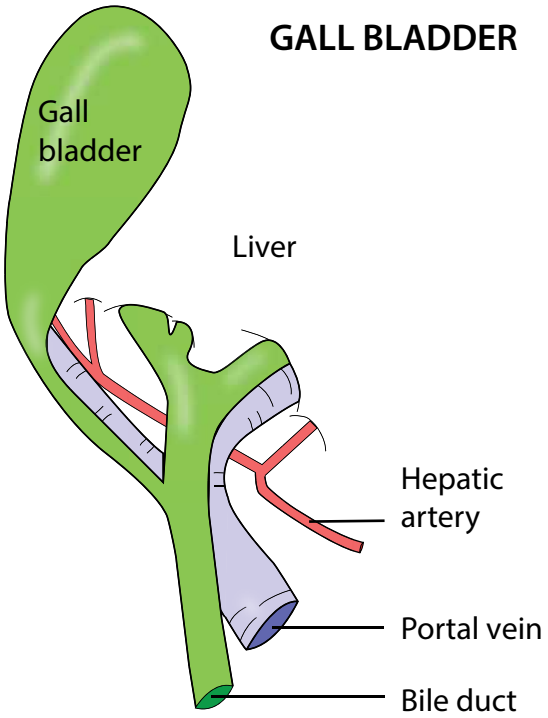


Neck with mucous cells leading to mucosal folds giving the spiral valve of Heister. When there is a swelling like this it is called Hartmann's pouch, usually formed by the presence, or previous presence of a stone

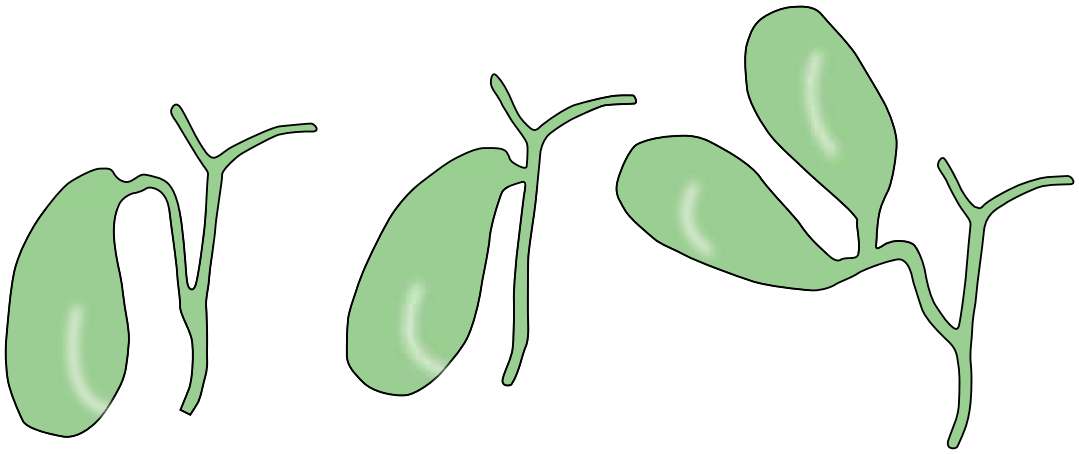
Hepatic artery - note that there are a few small arteries from bed of liver therefore there is usually no gangrene when cystic artery thromboses

GALL BLADDER

1. 50ml fibromuscular sac - stores and concentrates bile.
2. Lined by simple columnar epithelium. Mucous cells at neck only.
4. Veins directly to liver bed then to hepatic veins. Occasionally join portal vein
5. Lymphatics to porta hepatis
6. Parasympathetics and sympathetics transmitting referred pain
7. **Anterior:** Liver and abdominal wall. **Posterior:** Transverse colon and first part of duodenum



GALL BLADDER VARIATIONS

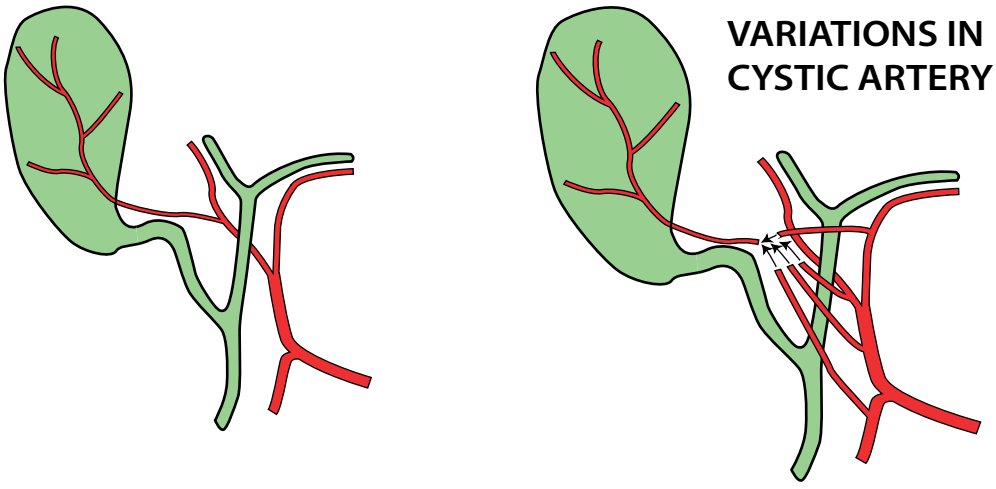


A long cystic duct joining the hepatic duct low, even behind the duodenum

Absent cystic duct. The gall bladder opens directly into the common hepatic duct

A rare double gall bladder resulting from a bifid embryonic diverticulum from the hepatic duct

VARIATIONS IN CYSTIC ARTERY

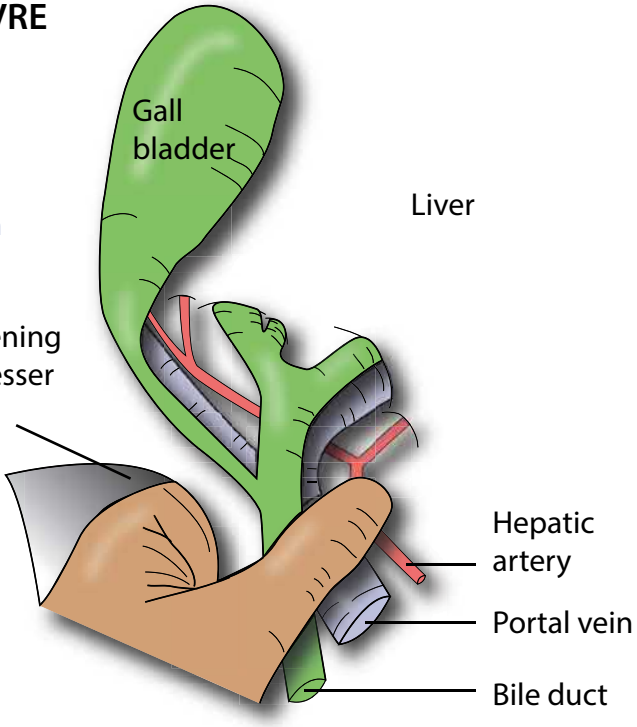


In 75% of people the cystic artery is given off in Calot's triangle from the right branch of the hepatic artery which lies posterior to the common hepatic duct

In 25% the cystic artery passes anterior to the common hepatic duct and arises from
1. Right branch of hepatic artery (14%)
2. Left branch of hepatic artery (6%)
3. Gastroduodenal artery (3%)
4. Main hepatic artery (2%)

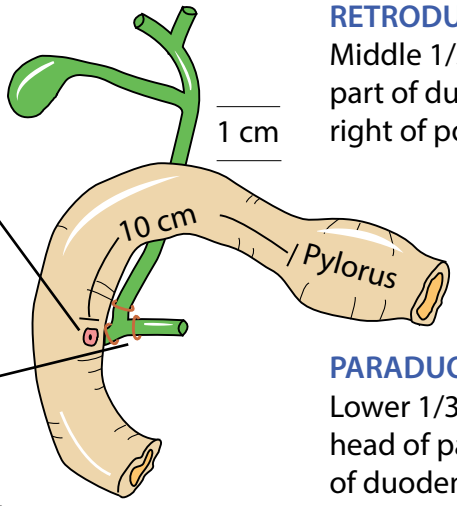
PRINGLE'S MANOEUVRE

Pressure is applied to both the portal vein and the hepatic artery to prevent bleeding from the liver



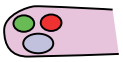
BILE DUCT (8CM LONG 8MM WIDE)

Ampulla of Vater opens into 2nd part of duodenum on posteromedial wall, 10cm from pylorus

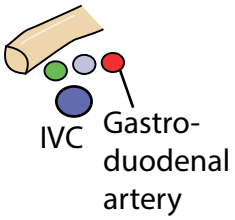


Sphincter of Oddi.
3 parts around -
1. Bile duct
2. Pancreatic duct
3. Ampulla

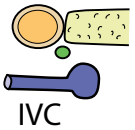
SUPRADUODENAL
Upper 1/3 in free edge of lesser omentum, with hepatic artery and portal vein



RETRODUODENAL
Middle 1/3 posterior to 1st part of duodenum, now to right of portal vein and on IVC



PARADUODENAL
Lower 1/3 in groove between head of pancreas and 2nd part of duodenum on right renal vein and IVC

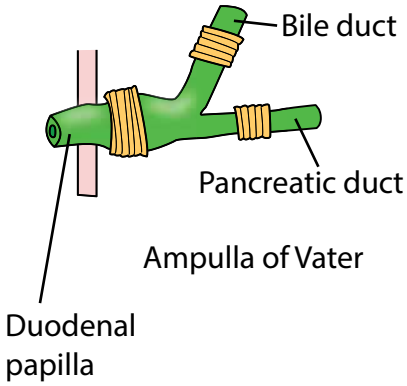


BILIARY DUCTS AND GALLBLADDER

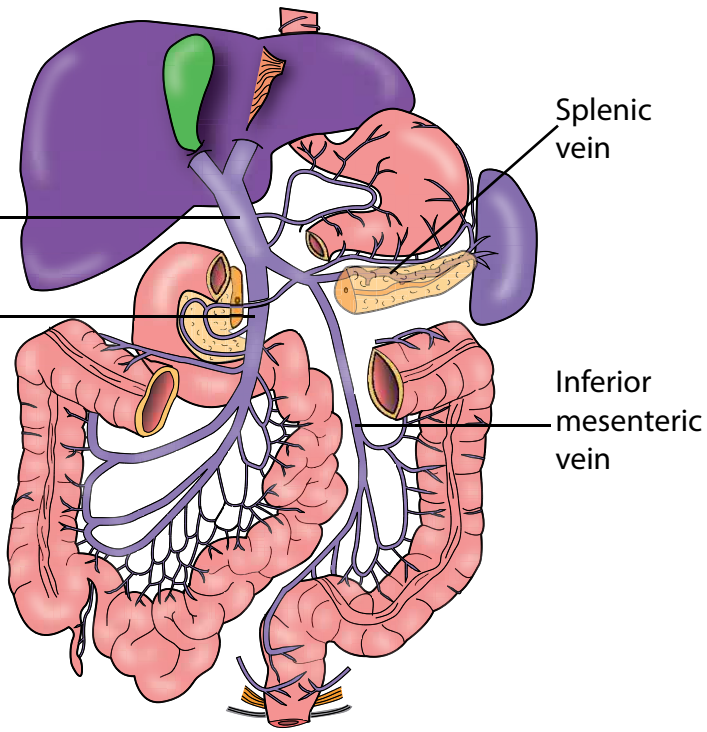
Blood:
Cystic, hepatic, gastroduodenal arteries
Nerves:
Parasympathetic - anterior vagus for contraction of gallbladder, relaxation of sphincter of Oddi (+ cholecystokinin from small bowel)
Sympathetic - coeliac ganglion, relaxes gallbladder
Sensation: General visceral afferent with sympathetics and somatic via phrenic referred to right shoulder tip

SPHINCTER OF ODDI

3 sphincters make up this sphincter of Oddi. Biliary is always present - others may be missing

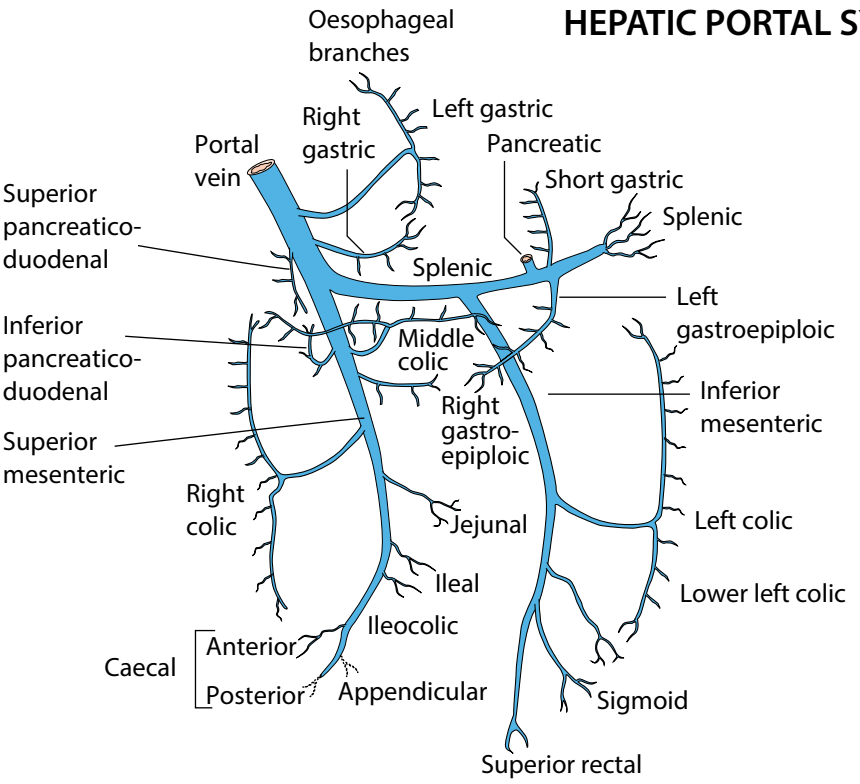


PORTAL VEIN & TRIBUTARIES



Drains venous blood from:
Whole bowel from lower 1/3 oesophagus to upper anal canal
Spleen, pancreas, gall bladder
To: Liver sinusoids
Formed by: Superior mesenteric and splenic veins behind neck of pancreas. Inferior mesenteric joins splenic at variable distances along it

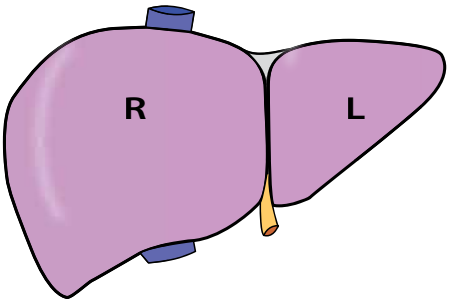
HEPATIC PORTAL SYSTEM



Drains: Venous blood from whole bowel from lower 1/3 oesophagus to upper anal canal, spleen, pancreas, gall bladder
To: liver sinusoids
Formed by: Superior mesenteric and splenic veins behind neck of pancreas. Inferior mesenteric joins splenic at variable distances along it

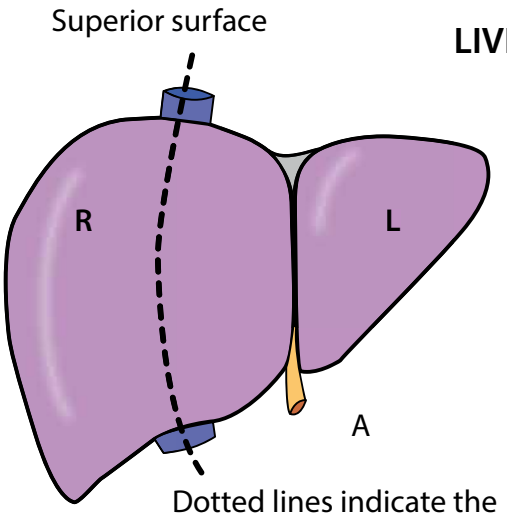
LIVER - GENERAL DESCRIPTION

Superior surface

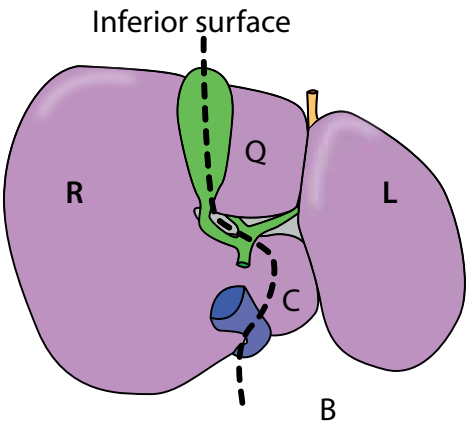


Wedge shaped, largest organ in body, weight 1500g
1500ml blood flow per minute (30% of cardiac output)
Lies: Right - 6-10 ribs/costal cartilages; Left - 6-7 costal cartilages
Surfaces: Anterior, superior, posteror, right - all smooth/convex. Postero-inferior (visceral) concave and many features
Supports: IVC and hepatic veins (+ ligamentum teres and peritoneum)
Nerve supply: Right vagus via coeliac ganglia, left directly to porta hepatis. Sympathetics on vessels
Reaches: T5 vertebra, nipples (4th intercostal space on right), xiphisternal joint

LIVER



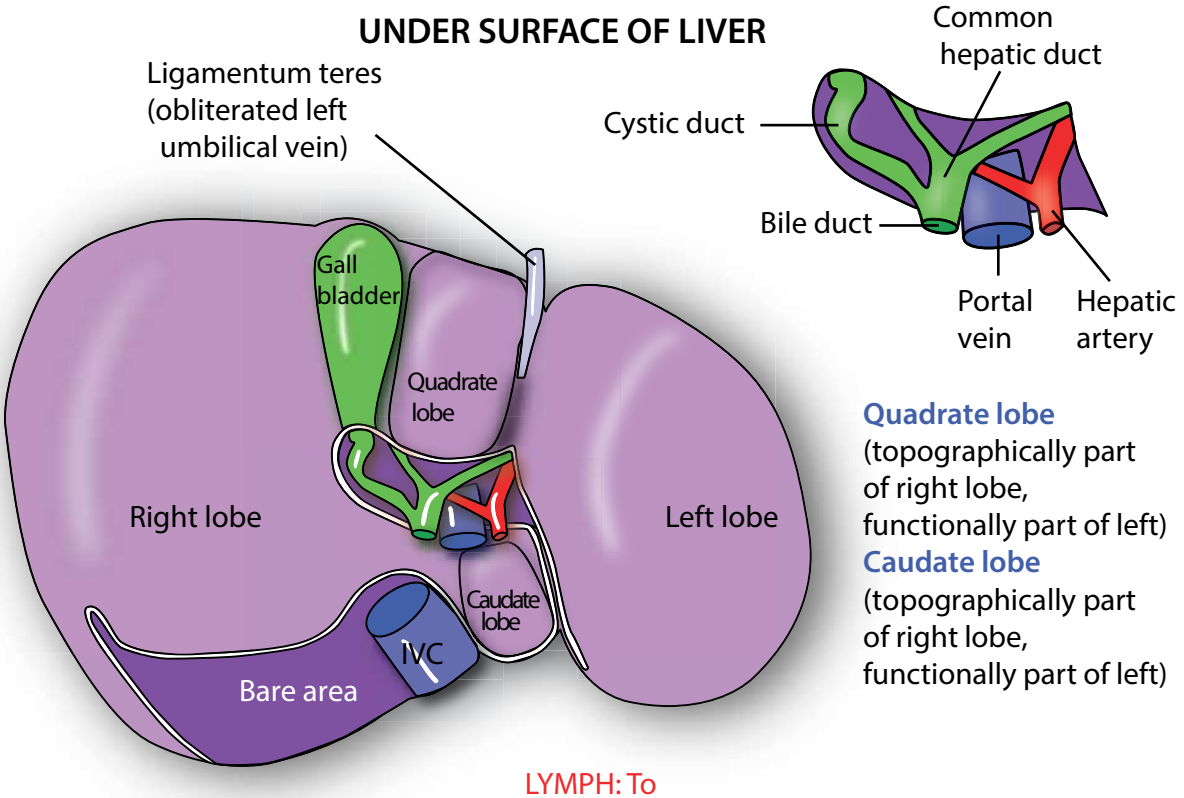
Dotted lines indicate the functional divisions of lobes of liver into left and right



Lobes:
C = caudate
Q = quadrate

Relations: Left and right subphrenic and subhepatic spaces. Note that left subhepatic is in the lesser sac
Main supports: Hepatic veins and IVC
Lymphatics: To coeliac, para-aortic, post. mediastinal, axillary and inguinal nodes

UNDER SURFACE OF LIVER



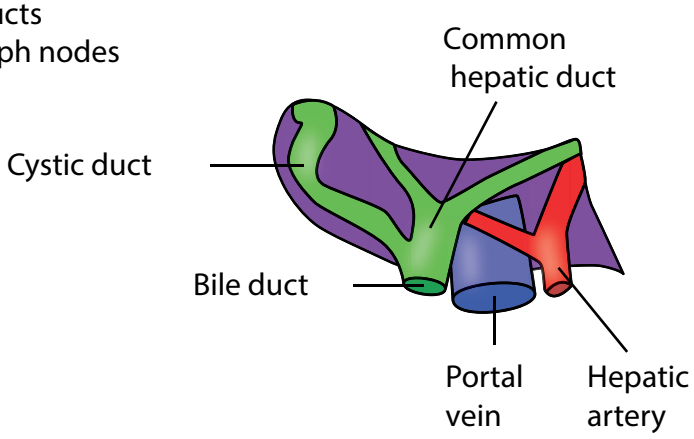
Quadrate lobe (topographically part of right lobe, functionally part of left)
Caudate lobe (topographically part of right lobe, functionally part of left)

LYMPH: To

LIVER - PORTA HEPATIS

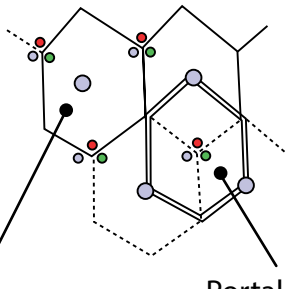
The **porta hepatis** is the area on the under surface of the liver at which the structures in the free edge of the lesser omentum enter/leave the liver. Peritoneum is reflected around it.
It contains the following structures:

- Portal vein
- Left/right branches of hepatic artery
- Left/right hepatic ducts
- Lymphatics and lymph nodes
- Autonomic nerves



LIVER

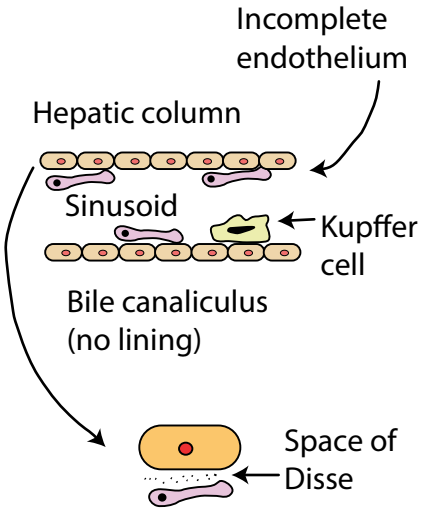
LOBULES



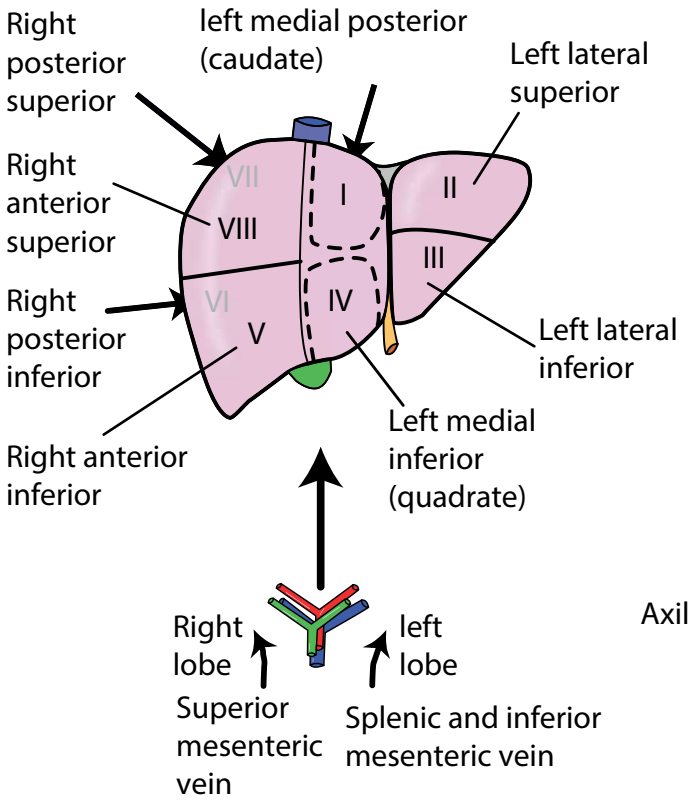
Hepatic lobule (anatomical lobule -central hepatic vein and 3 biliary triads)

Portal lobule (physiological lobule - central triad radiating to 3 hepatic veins)

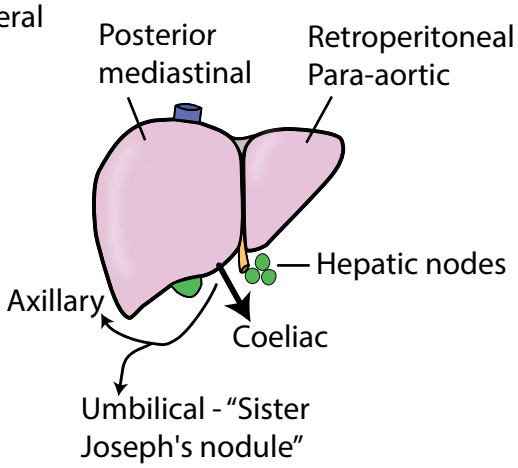
HISTOLOGY



LIVER - PORTOBILIARY SEGMENTATION

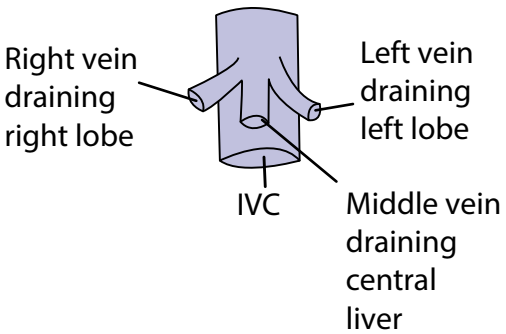


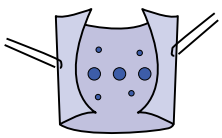
LYMPHATIC DRAINAGE OF LIVER



HEPATIC VEINS

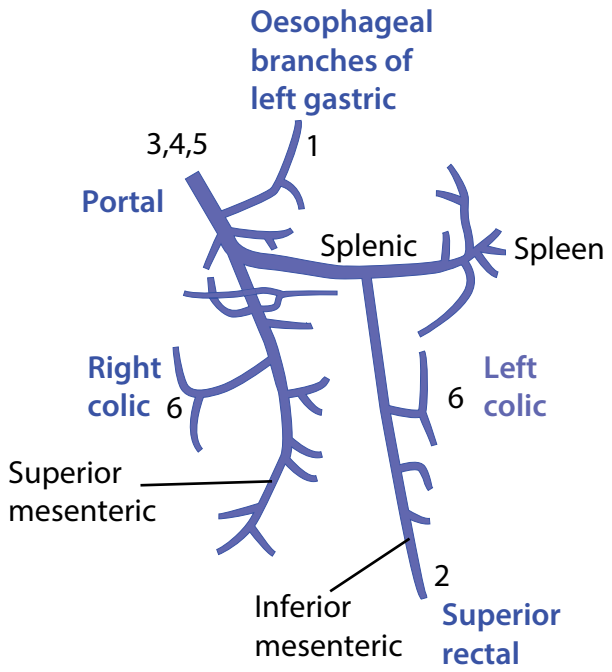
These veins drain the "cleansed" blood back into the systemic circulation from the liver. They do not follow the portobiliary segmentation. The veins suspend the liver from the inferior vena cava and are helped by the peritoneal reflections





Accessory veins drain the liver directly into the (opened) IVC

PORTOSYSTEMIC ANASTOMOSES 1



1 Lower oesophagus
Portal: Oesophageal branches of left gastric veins
Systemic: Azygos veins

2 Upper anal canal
Portal: Superior rectal vein
Systemic: Middle/inferior rectal veins

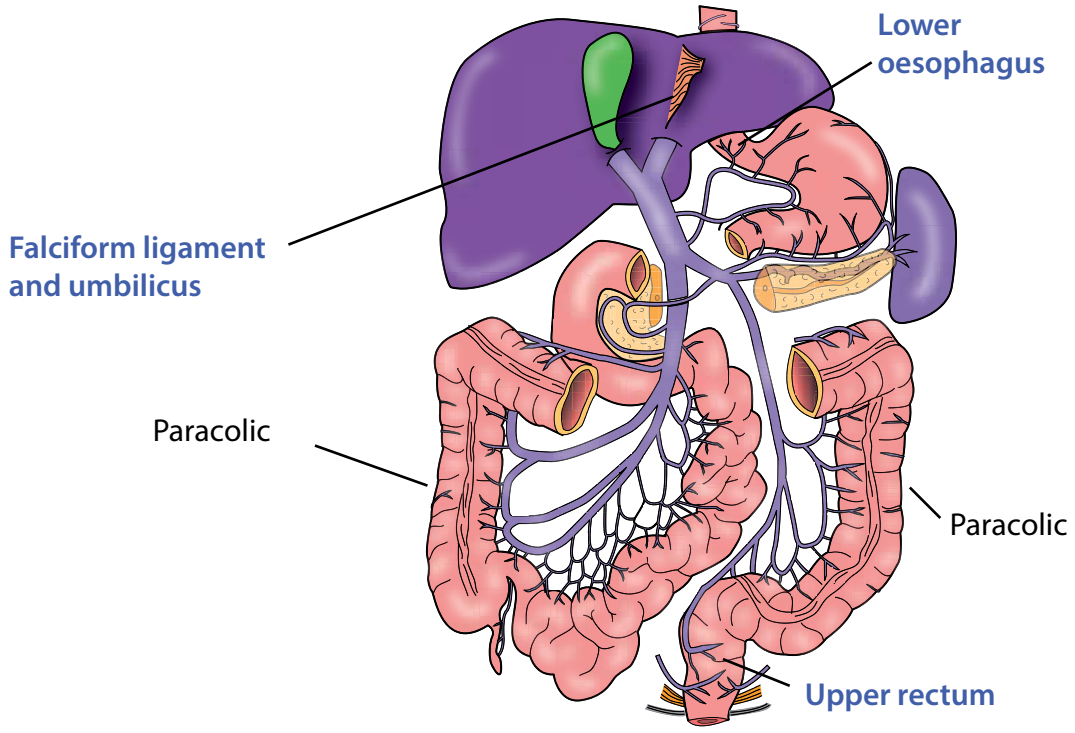
3 Umbilical
Portal: Veins of ligamentum teres
Systemic: Superior/inferior epigastric veins

4 Bare area of liver
Portal: Hepatic/portal veins
Systemic: Inferior phrenic veins

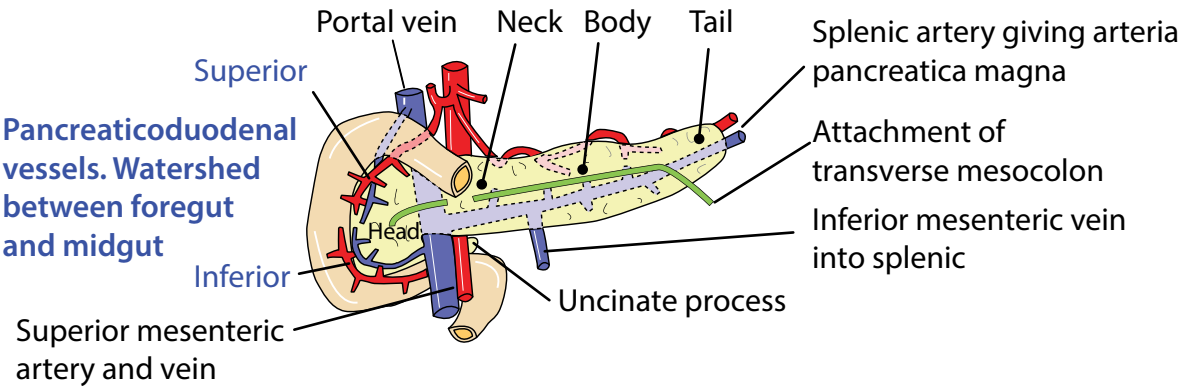
5 Patent ductus venosus (rare)
Portal: Left branch of portal vein
Systemic: Inferior vena cava

6 Retroperitoneal
Portal: Colonic veins
Systemic: Body wall veins

PORTOSYSTEMIC ANASTOMOSIS 2

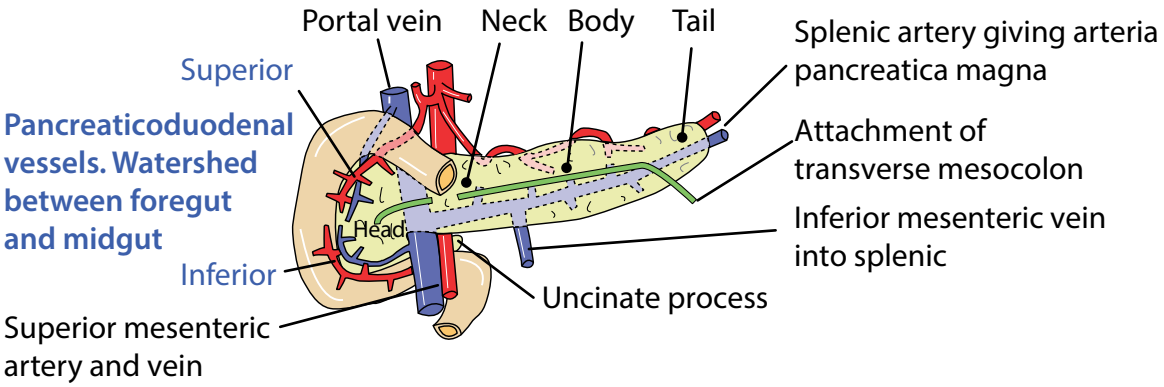


PANCREAS 1



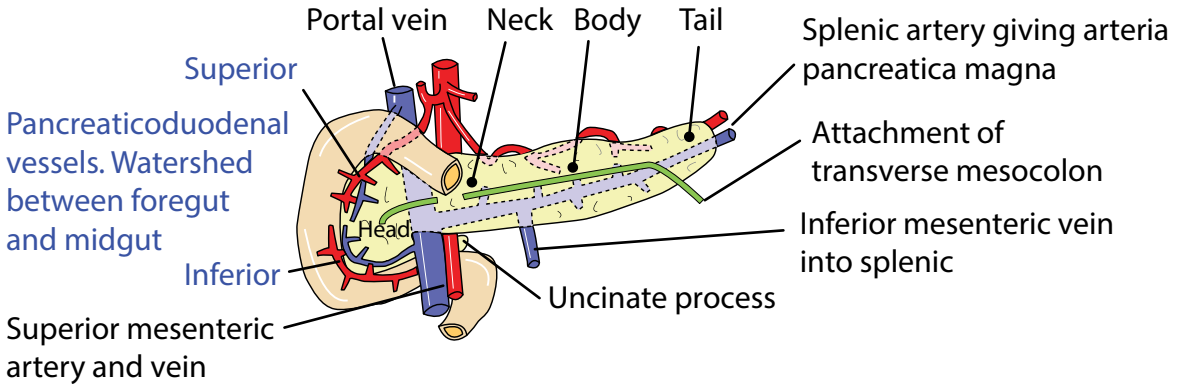
Retroperitoneal, Neck in the transpyloric plane, 15cm long, lobulated with fine capsule. Islets of Langerhans between alveoli. Exocrine volume much greater than endocrine **Main duct (Wirsung)** leads to ampulla of Vater. Accessory duct (**Santorini**) from uncinate process opens proximally, may be absent, often communicates with main duct
Secretion: Alveoli of serous secretory cells lead to ductules then to principal ducts. Amylase. Secretin causes juice rich in bicarbonate; cholecystokinin causes juices rich in enzymes - trypsinogen, chymotrypsinogen anc pancreatic lipase. Alpha islet cells give glucogon, beta cells give insulin, delta give somatostatin which inhibits secretion of pancreatic hormones including glucogon and insulin. Pancreatic polypeptide is produced by the tail of the pancreas.

PANCREAS 2



Arteries: Gastroduodenal, inferior/superior pancreaticoduodenal, arteria pancreatica magna from splenic.
Veins: To portal system. Pancreaticoduodenal. Superior to portal, inferior to superior mesenteric
Lymphatics: In groove between head and duodenum and root of arteries
Nerves: Parasympathetic (posterior vagus) to stimulate exocrine secretion. Sympathetic for vasoconstriction and pain (T6-10)

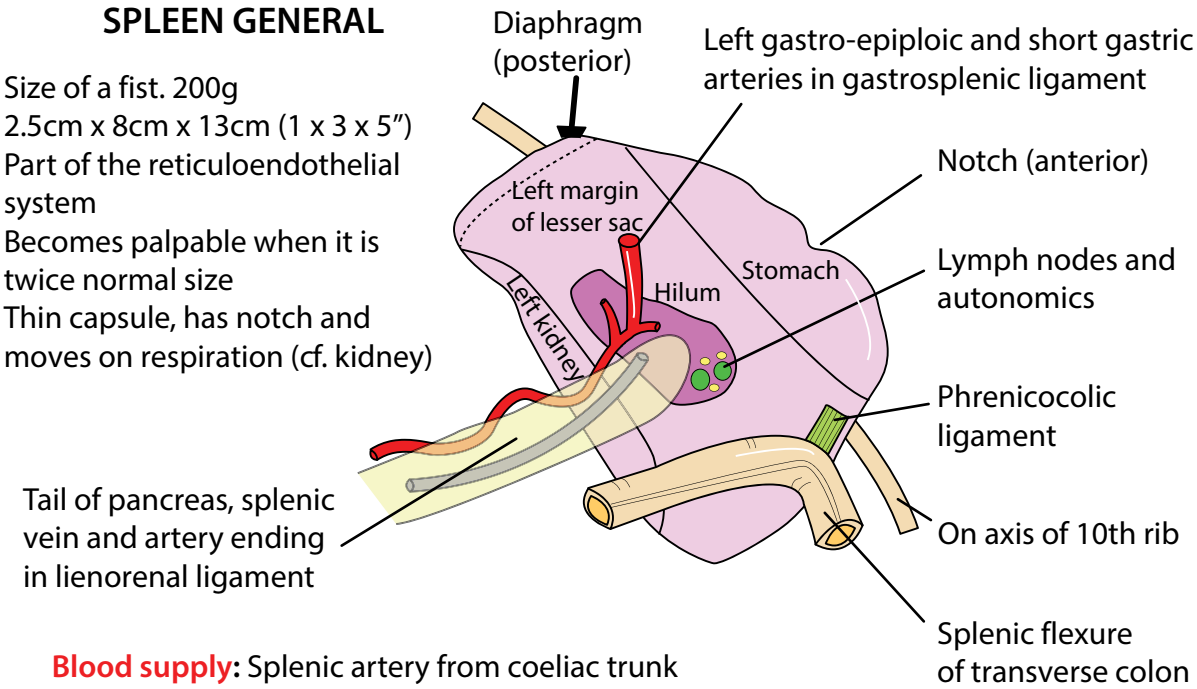
PANCREAS: RELATIONS



Anterior: Lesser sac, pylorus, 1st part of duodenum, transverse mesocolon, stomach; superior mesenteric artery and vein lying between body and uncinate process
Superior: Splenic artery
Lateral on right: 2nd part of duodenum, ampulla of Vater
Lateral on left: Hilum of spleen
Posterior: Left crus of diaphragm, psoas, right renal vein, inferior vena cava, bile duct, spleen, left renal vessels, left kidney, left suprarenal gland, coeliac plexus, inferior mesenteric vein, splenic vein, portal vein, aorta; superior mesenteric artery and vein

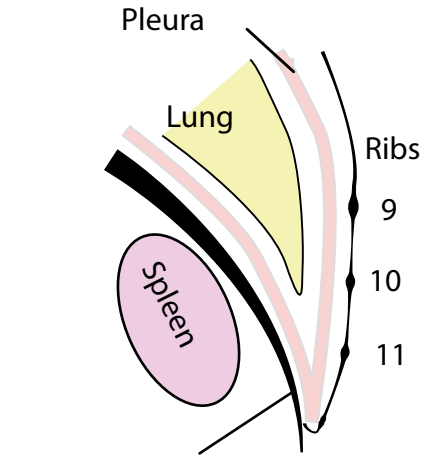
SPLEEN GENERAL

- Size of a fist. 200g
- 2.5cm x 8cm x 13cm (1 x 3 x 5")
- Part of the reticuloendothelial system
- Becomes palpable when it is twice normal size
- Thin capsule, has notch and moves on respiration (cf. kidney)



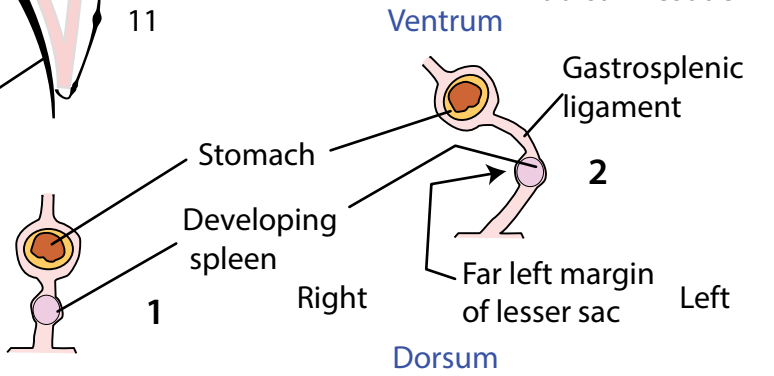
Blood supply: Splenic artery from coeliac trunk
Venous drainage: Splenic vein to portal system
Lymph: Coeliac (para-aortic)
Nerve: Sympathetic from coeliac plexus

SPLEEN - RELATIONS, FUNCTION AND DEVELOPMENT



Functions:
Erythropoeisis, effete erythrocyte removal, immune defence (beta cells) and blood storage

DEVELOPMENT
In dorsal mesoderm

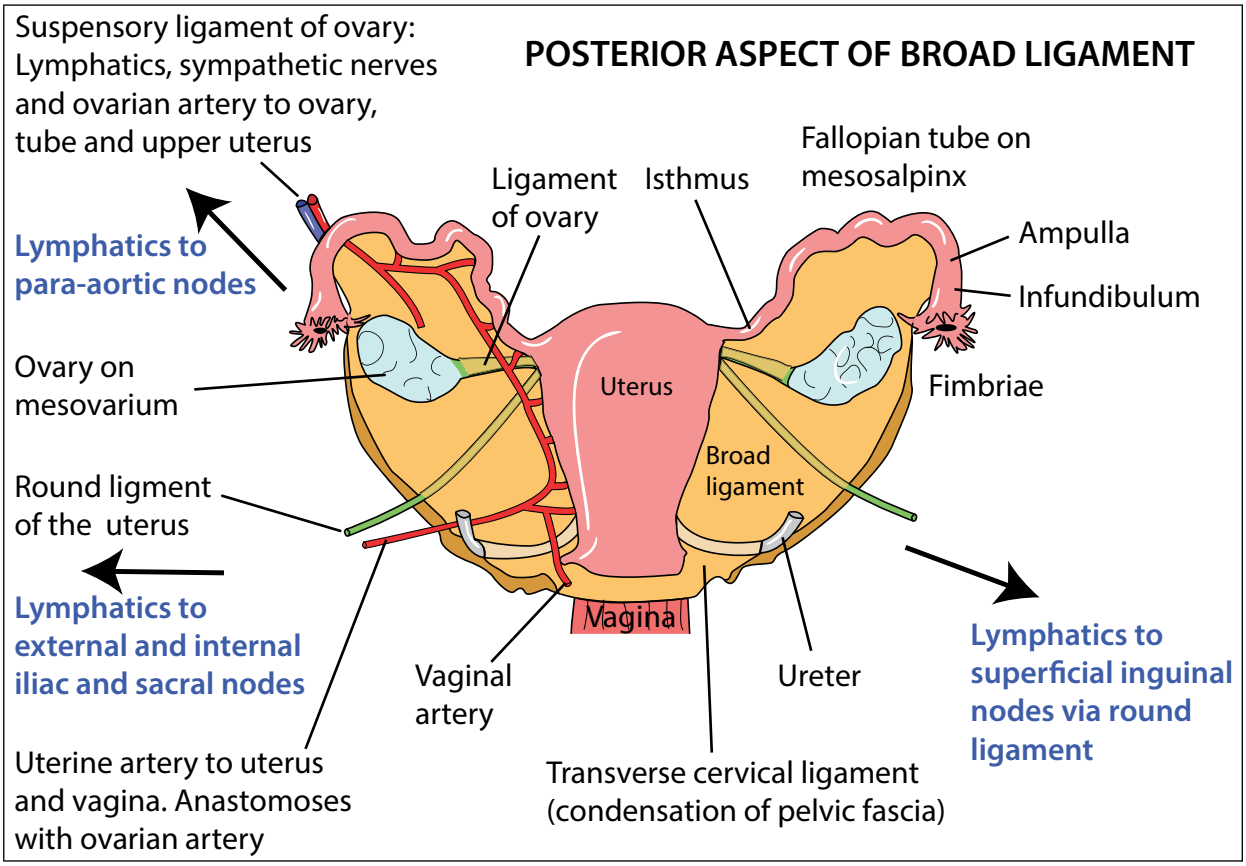


4.6 Female and Male Genitourinary and Renal Tracts

UTERUS AND BROAD LIGAMENT

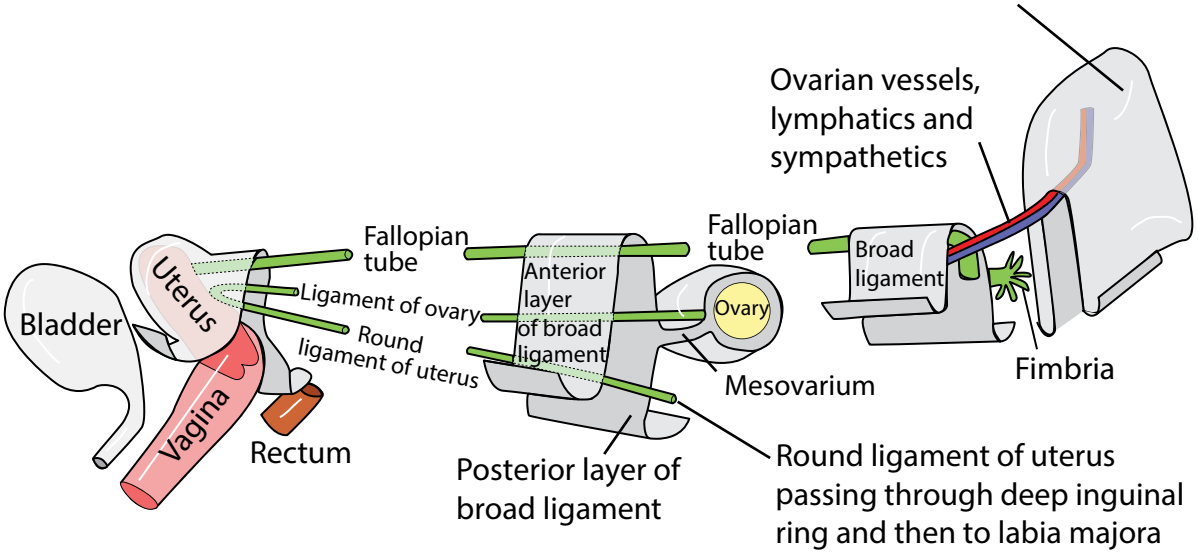
BROAD LIGAMENT: A double layer of peritoneum draped over uterus and tubes. Between the two layers are arteries, veins, round ligament, ligament of ovary and lymphatics. The ovary is partially covered by a separate posterior fold of the broad ligament (mesovarium) but the surface of the ovary is devoid of peritoneum to allow exit of the ova.
FALLOPIAN TUBES: Lie in the upper edge of the broad ligament (mesosalpinx). they are 10cm long. Outer longitudinal and inner circular muscle and a ciliated columnar lining. Their distal ends protrude out of the posterior layer of the broad ligament and lie free in the peritoneal cavity.
LIGAMENT OF THE OVARY: Extends between the ovary and the side wall of the uterus.
ROUND LIGAMENTS OF UTERUS: Extend from the side wall of the uterus to the labia majora via the inguinal canal. The ligament of the ovary and the round ligament are in continuity and represent the homologue of the gubernaculum in the male.
THE URETERS: Pass through the base of the broad ligament in close relationship to the uterine artery, level with the uterine os.
UTERINE ARTERY: Supplies the uterus, vagina and anastomoses with ovarian artery.
NERVES: Sensory: General visceral afferents via pelvic plexus. In parasympathetics from cervix and in sympathetics for rest of uterus and tube. Parasympathetics motor to uterus and tube. No parasympathetics to ovary.

POSTERIOR ASPECT OF BROAD LIGAMENT

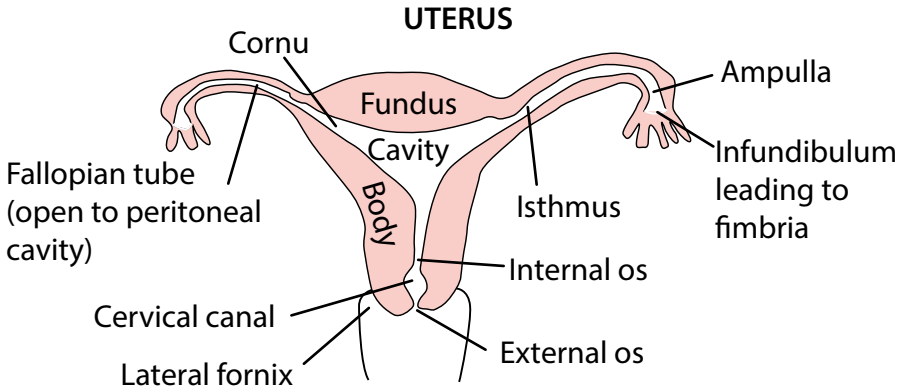


ANTERIOR VIEW OF LEFT SIDE OF BROAD LIGAMENT

Suspensory ligament of the ovary is a double fold of peritoneum at the lateral end of the broad ligament where the ovarian neurovascular bundle leaves the posterolateral abdominal wall to enter the broad ligament



UTERUS



Pear shaped. Usually anteverted to 90 degrees and anteflexed to 170 degrees

Histology: No submucosa. Cervix: Tall columnar epithelium becoming squamous outside, alkaline mucus. Rest of uterus: Endometrium with glands, arterioles, smooth whorls of muscle, columnar epithelium.

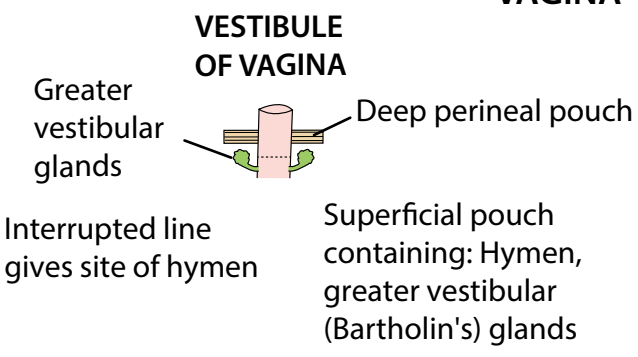
Nerves: Motor: Smooth muscle activated by parasympathetic, relaxed by sympathetic. Both from pelvic plexus. Sensory: Sympathetic for uterus. Parasympathetic cervix only.

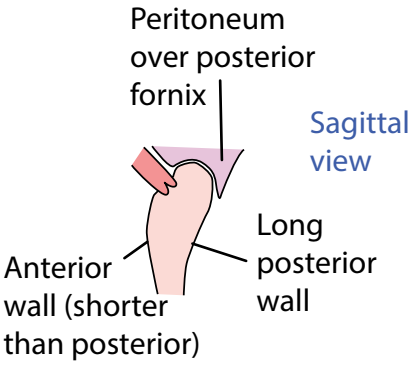
Blood supply: Uterine artery with some anastomosis from ovarian artery.

Venous drainage: Highly plexiform to vesical and rectal plexuses.

Relations: **Anterior** - vesicouterine pouch, posterior/superior bladder anterior fornix, small bowel. **Posterior** - Pouch of Douglas, ileum, sigmoid. **Lateral** - Uterine vessels, ureter, lateral fornix, broad ligament

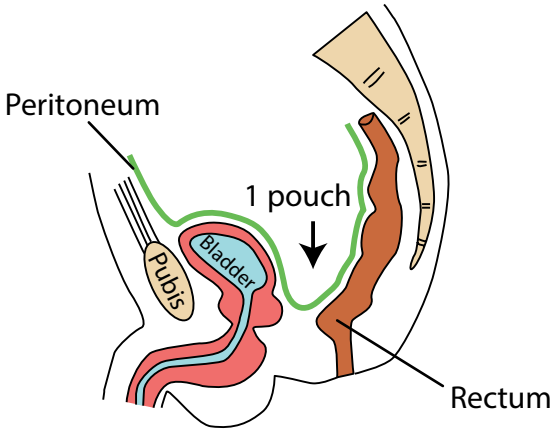
VAGINA

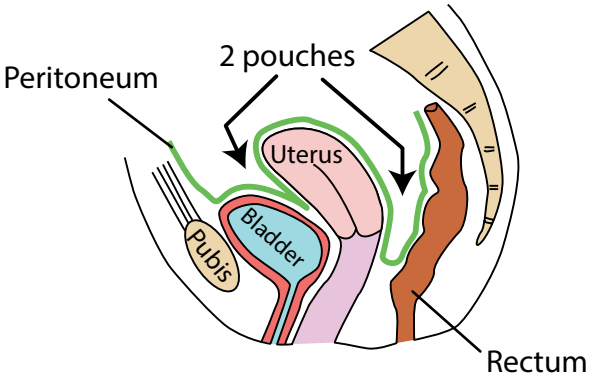




10cm long, potential space apart from posterior fornix which is real space
Fornices: Anterior, lateral and posterior
Artery: Vaginal branch of uterine, middle rectal, inferior vesical
Veins: Pelvic floor plexus to internal iliac
Nerves: Autonomic from pelvic plexus for vasoconstriction, smooth muscle action, stretch sensation.
Somatic: Perineal branches of pudendal, ilio-inguinal
Lymphatics: External/internal iliac, sacral, superficial inguinal
Support: levator ani (pubovaginalis) and perineal body
Structure: Non-keratinising stratified squamous epithelium, smooth muscle, sweat glands, no mucous glands
Relations: **Anterior**: Bladder, urethra. **Posterior**: Recto-uterine pouch, rectum, perineal body, anal canal.
Lateral: Ureter, uterine artery, levator ani, urogenital diaphragm

COMPARISONS OF PELVIC PERITONEUM IN THE MALE AND FEMALE PELVIS

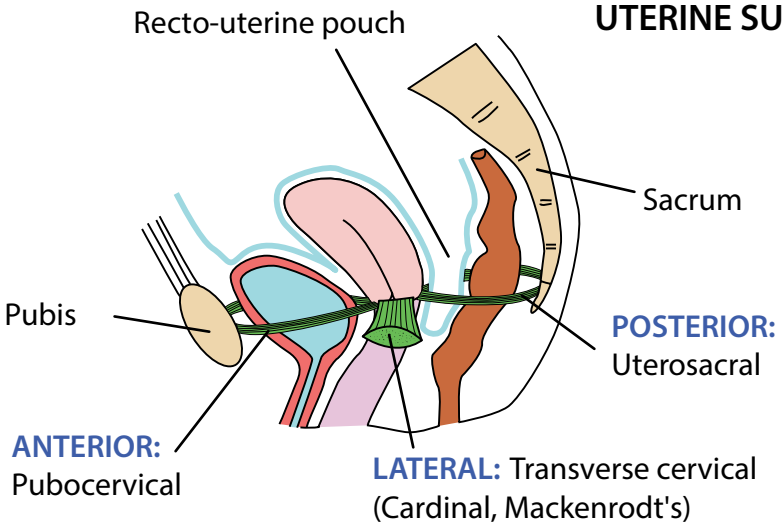




MALE: In males the peritoneum passes from the posterior surface of the bladder to the lower third of the rectum, giving a single - **rectovesical pouch**

FEMALE: In females the uterus protrudes into the pelvis between the bladder and rectum giving two pouches. The **vesicouterine pouch** anteriorly and the **rectouterine pouch** (of Douglas) posteriorly.

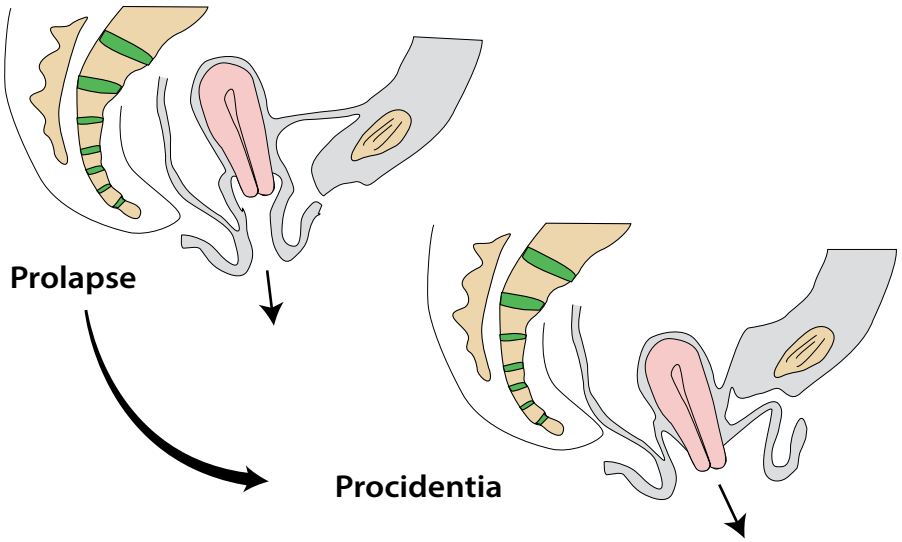
UTERINE SUPPORTS



These ligaments/Supports are condensations of fascia known as parametrium.

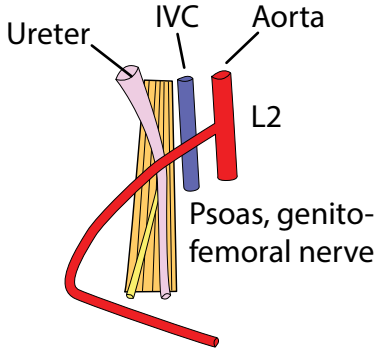
NOTE: Suspensory ligament of ovary, round ligament and broad ligament are **NOT** primarily supportive

UTERINE PROLAPSE AND PROCIDENTIA

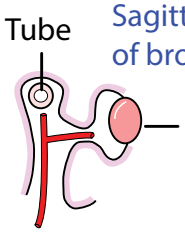


As the uterus passes inferiorly through the opening of the pelvic floor there is a substantial risk of the ureters lying alongside it becoming obstructed and leading to acute bilateral hydroureteronephrosis and acute renal impairment.

GONADAL VESSELS



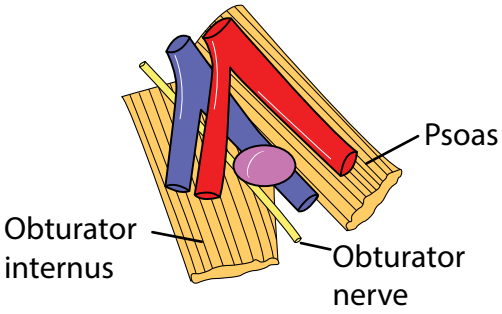
Gonadal artery enters suspensory ligament of ovary at pelvic brim



Sagittal section of broad ligament

Ovary with low columnar epithelium but NO peritoneum

OVARY RELATIONS

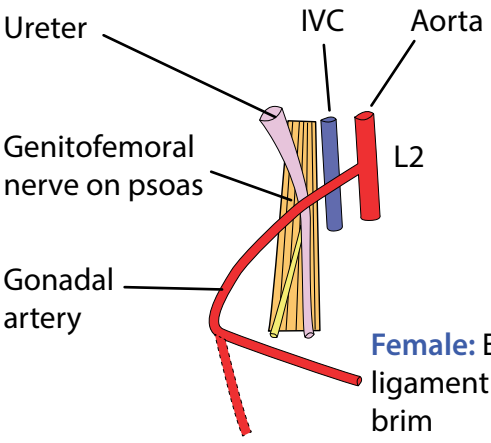


Ovary lies in fossa between bifurcation of common iliac artery, on obturator nerve and external iliac vein. Overlaid by ileum and sigmoid colon

Almond shaped - 4cm x 2cm
Attached to posterior aspect of broad ligament by mesovarium
Attached to uterus by ligament of ovary
Artery: Ovarian from aorta at L2
Vein: Left to left renal. Right to IVC
Lymphatics: Para-aortics. (Inguinal via round ligament and to opposite ovary in disease)

GONADAL VESSELS

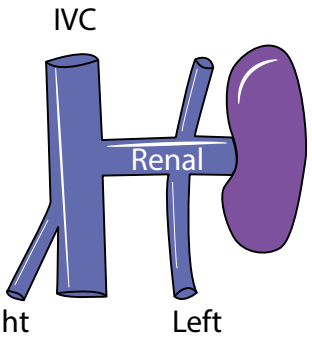
ARTERIES



Female: Enters suspensory ligament of ovary at pelvic brim

Male: Across pelvic brim, into deep inguinal ring

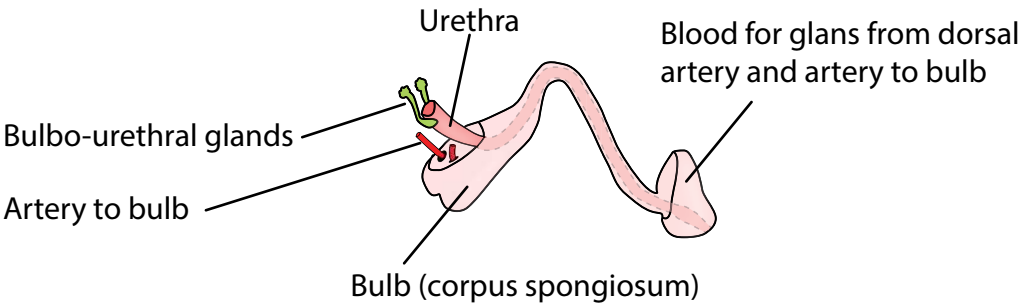
VEINS



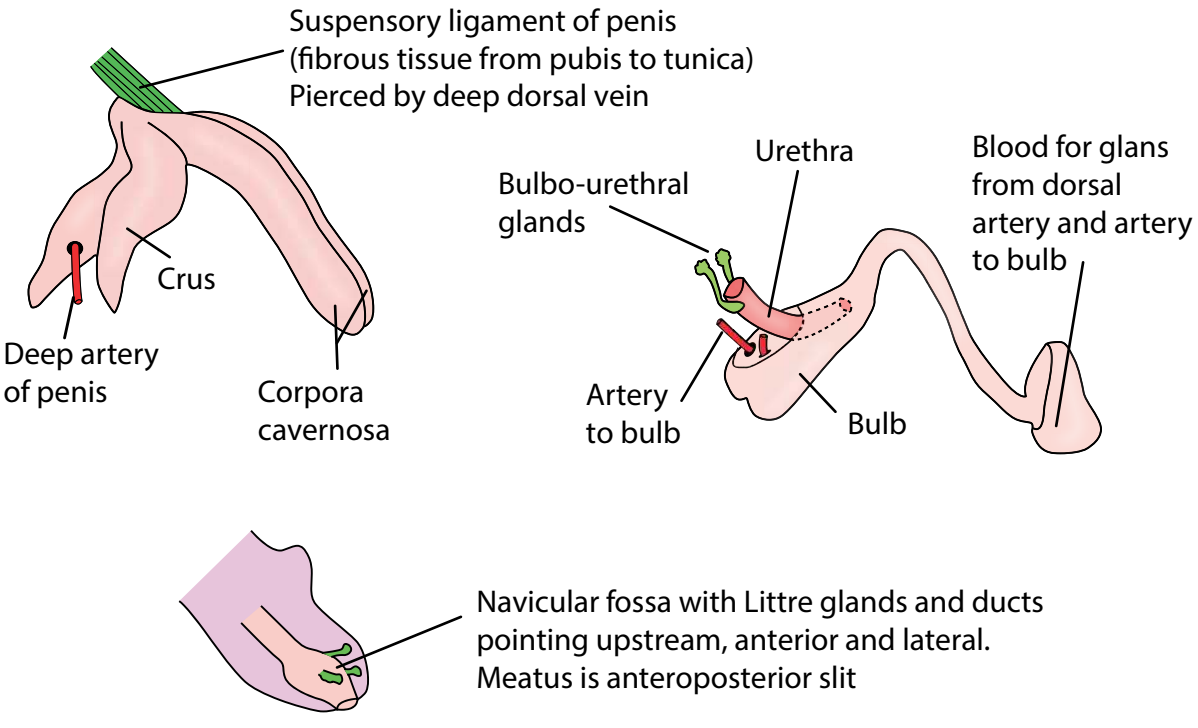
LYMPHATICS from both gonads follow the artery up to the para-aortic nodes - NOT to inguinal nodes

MALE URETHRA

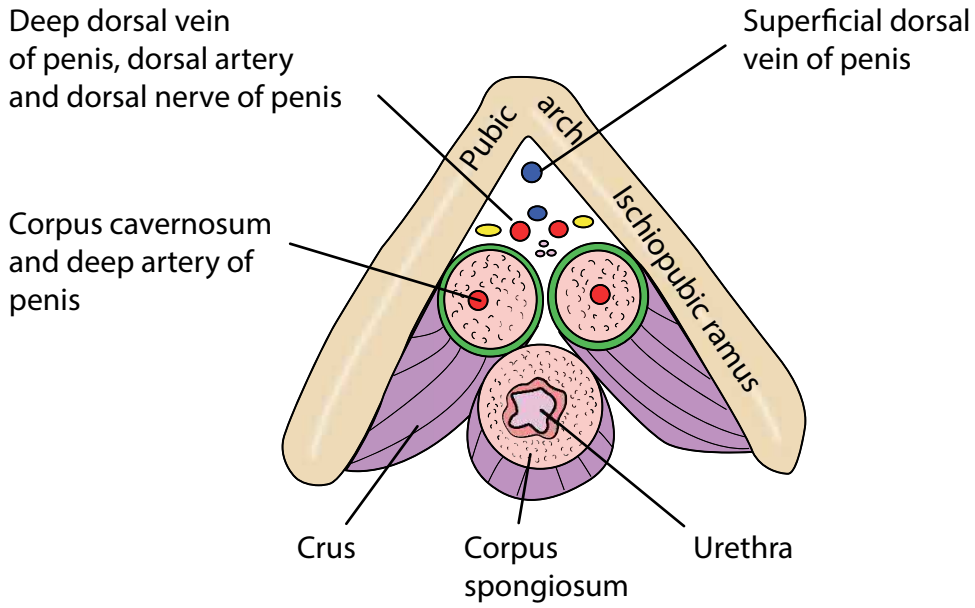
Prostatic approximately 2.5cm and **membranous** 2cm together make the posterior urethra.
Bulbous and **pendulous** make the anterior urethra. Approximately 20cm.
Blood: Artery to bulb to both glans and corpus spongiosum; Deep artery of penis to corpus cavernosum; Dorsal artery of penis to skin, fascia, glans; Urethral artery from dorsal artery
Veins: Superficial and deep dorsal veins of penis
Lymph: Skin to superficial inguinal nodes. Glans, corpora, urethra to deep inguinal nodes
Nerves: Posterior scrotal to skin and glans. Pudendal gives dorsal nerve of penis. Sympathetics for ejaculation, Parasympathetics to corpora for erection.
Receives: Ejaculatory ducts, bulbourethral glands, urethral glands



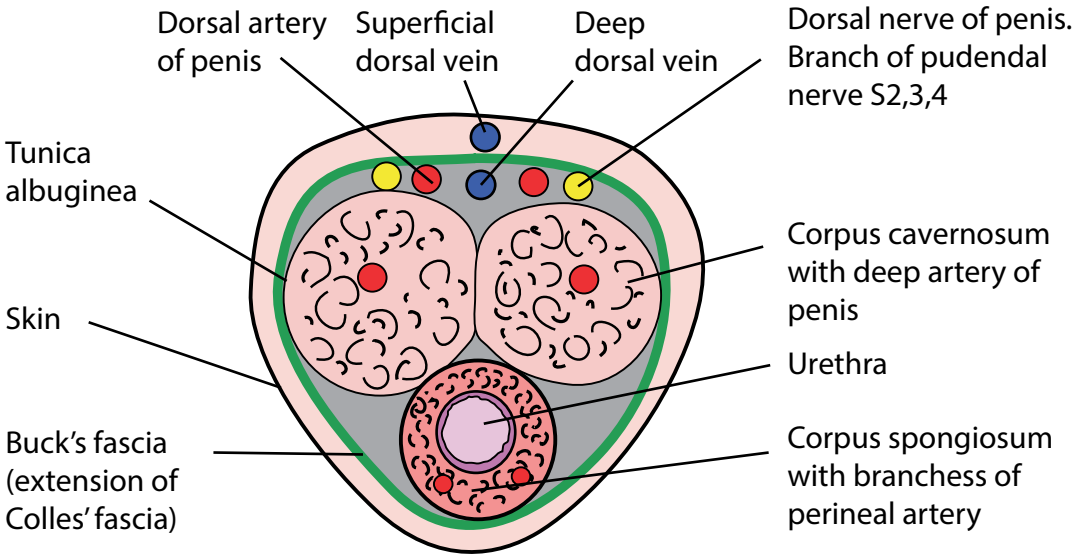
PENIS - CONSTITUENT PARTS



PENIS - CORONAL SECTION AT PUBIS

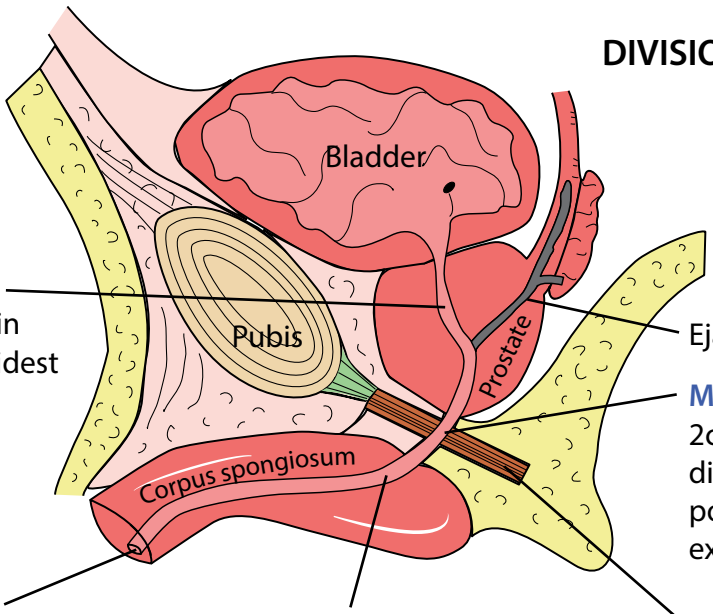


CROSS SECTION OF MID SHAFT PENIS



Superficial dorsal vein drains to superficial external pudendal and then great saphenous. Deep dorsal vein drains to vesicoprostatic plexus. Lymph to deep and superficial inguinal nodes

DIVISIONS OF URETHRA



Prostatic
2-4cm within prostate. Widest part

Ejaculatory duct

Membranous
2cm within urogenital diaphragm (deep perineal pouch). Surrounded by external sphincter

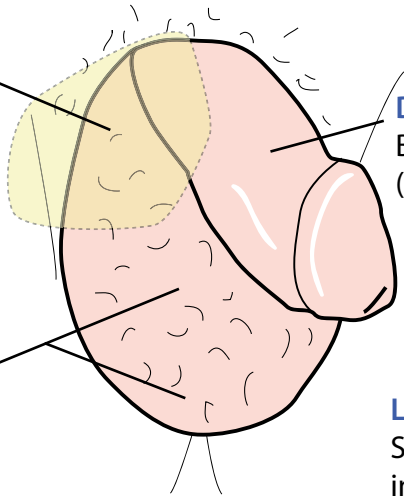
Urogenital diaphragm

Penile (pendulous)
Between bulbous and glans. Combined length 15cm

Bulbous
Within widest part of corpus spongiosum posteriorly

SENSORY SUPPLY TO SCROTUM AND PENIS

Ilioinguinal nerve
L1 from lumbar plexus (side of upper penis, scrotum and inner thigh

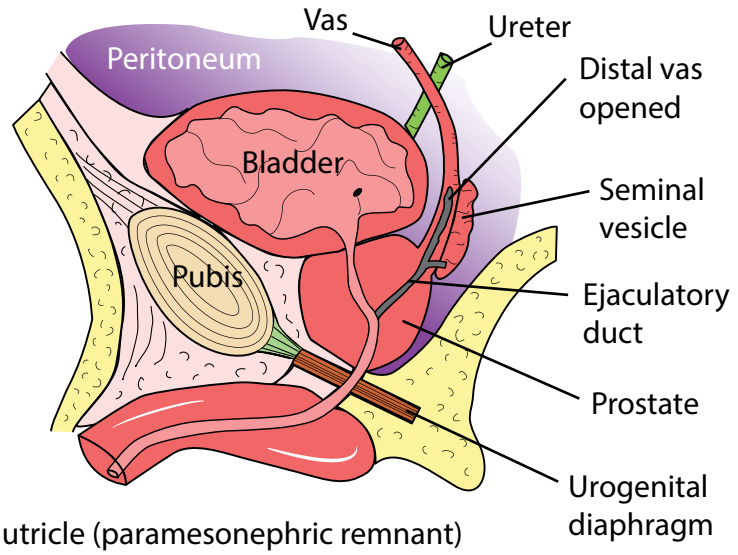


Dorsal nerve of penis
Branch of pudendal (S2,3,4)

Anterior scrotum: Scrotal branches of perineal nerve
(pudendal (S2,3,4)
Posterior scrotum: Posterior femoral cutaneous nerve
(S1,2,3)

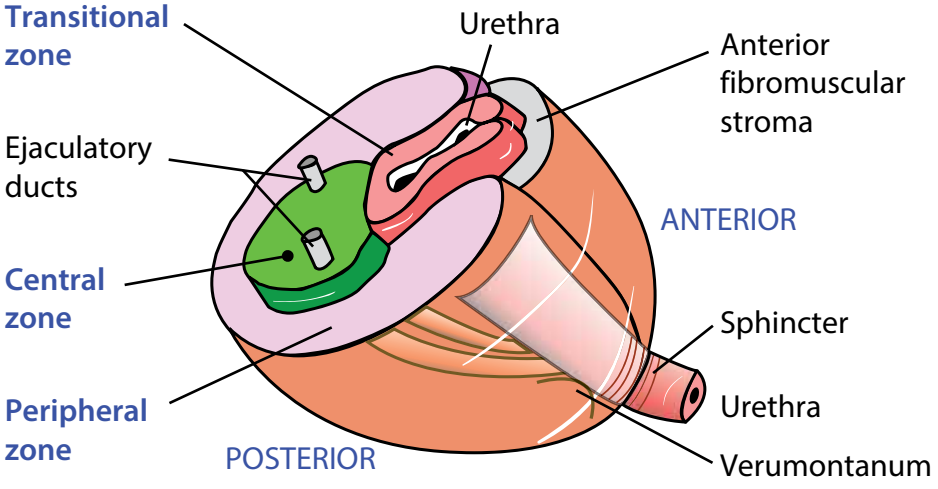
Lymph
Superficial to superficial inguinal nodes, deep to internal iliac

PROSTATE



- Pyramidal shape
- Posterior groove
- Size of chestnut (2 x 3 x 4cm)
- Sits on urogenital diaphragm
- Intrinsic urethral mechanism around it
- Gives nutrients for sperm
- 30% ejaculate volume
- Urethra runs through it
- True and false capsules
- Ejaculatory ducts and prostatic utricle (paramesonephric remnant) open onto verumontanum in floor of prostatic urethra
- **Veins:** Preprostatic plexus - valveless (to vertebral plexuses)
- **Arteries:** Inferior vesical, middle rectal, internal pudendal
- **Nerves:** Sympathetic for ejaculation and smooth muscle contraction. Parasympathetic for erection and secretomotor of acini
- **Lymph:** Iliac nodes

AXIAL PROSTATE TO SHOW "ZONAL" LOBES



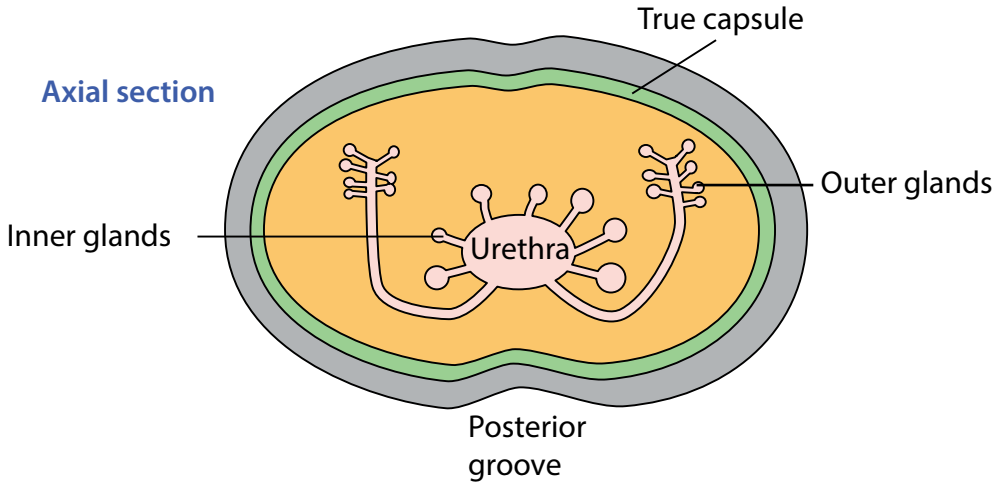
Dorsal vein of penis draining into the preprostatic venous plexus then the iliac veins

Central zone: Surrounds ejaculatory ducts all the way to verumontanum

Transitional zone: Surrounds the urethra. Liable to nodular benign enlargement (stroma and glandular) from 40 yrs onwards. Causes: ageing, circulating androgens

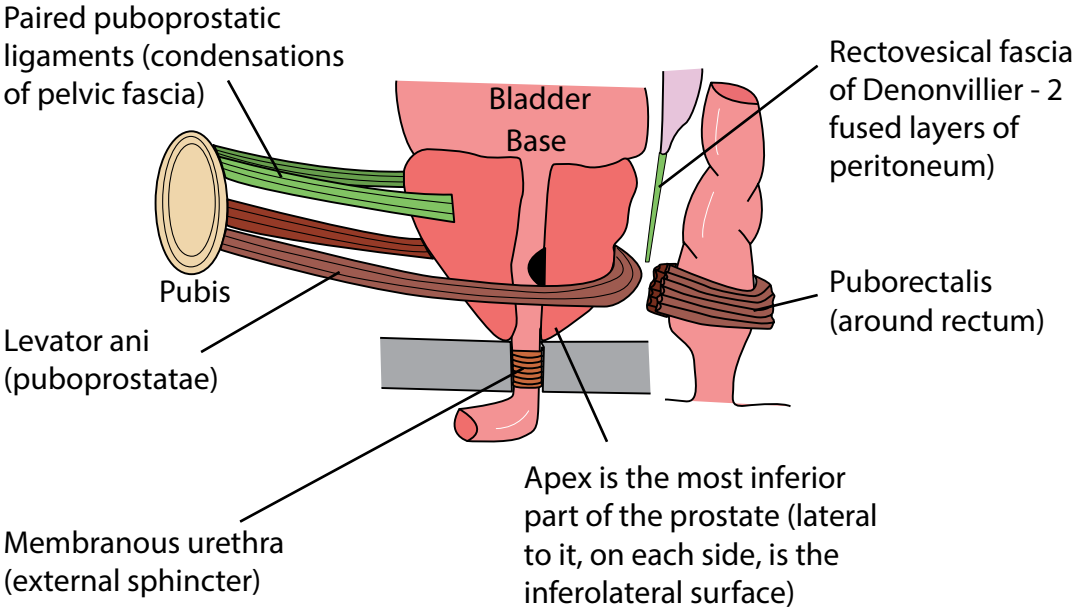
Peripheral zone: Surrounds the other two zones. 70% of cancers start here. It is pushed peripherally by benign enlargement and compressed

PROSTATIC DUCTS

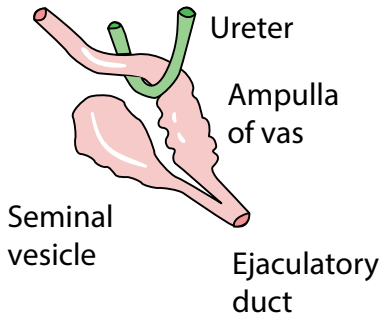


- Prostatic ducts open into urethra as two groups: inner and outer
- True fibrous capsule, but a false "capsule" develops when hypertrophic prostatic tissue compresses the posterior lobe (peripheral zone)

PROSTATIC LIGAMENTS AND SUPPORTS

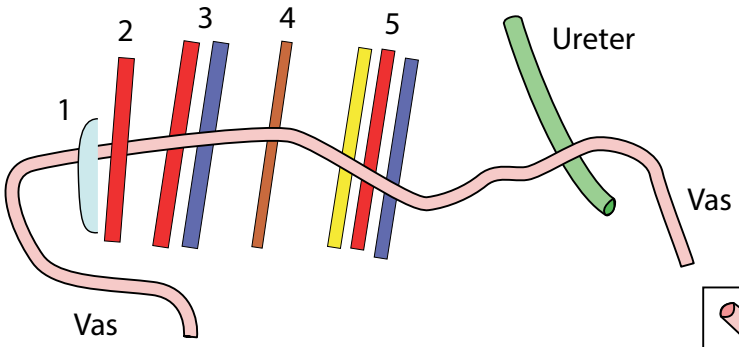


SEMINAL VESICLES

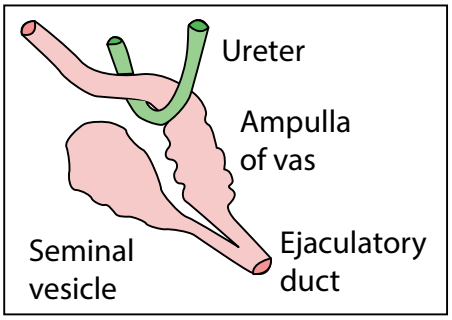


The seminal vesicles are thin walled sacs lying posterior to the bladder and prostate, producing 70% of the ejaculate but **containing NO sperm**. The remaining 30% is produced by the prostate. They produce fructose with medicolegal importance in identifying seminal fluid. They are covered posteriorly by Denonvillier's fascia.
Arterial supply: Vesical or middle rectal arteries.
Nerve supply: Post-ganglionic sympathetic fibres.
Structure: The lining is outer longitudinal and inner circular smooth muscle - needed for ejaculation. The ejaculatory ducts are formed by the distal vas and the seminal vesicle duct and enter the posterior urethra at the verumontanum.

URETER AND VAS RELATIONS

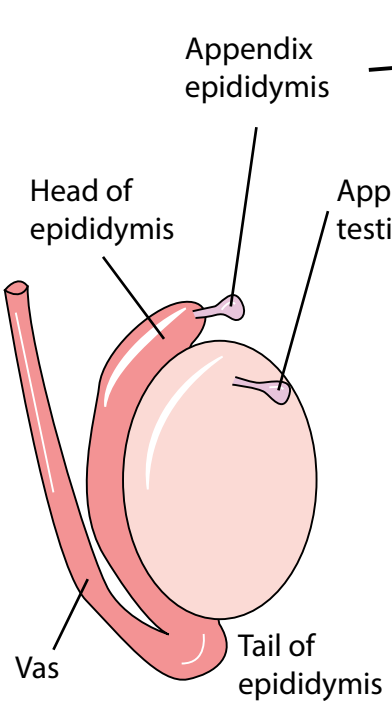


1. Medial edge of deep inguinal ring
2. Inferior epigastric artery
3. External iliac vessels
4. Obliterated umbilical artery
5. Obturator neurovascular bundle



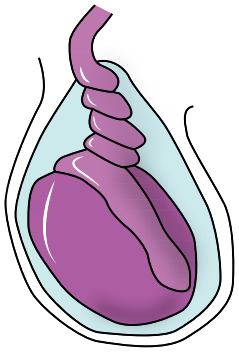
The ductus (vas) deferens is about 45cm long and is a highly muscular (smooth muscle) tube. It starts at the lower pole of the epididymis and ends at the ejaculatory duct. It lies just beneath the peritoneum for most of its intra-abdominal course. It is supplied by a branch of either the superior or inferior vesical artery. Motor activity during ejaculation is controlled by post-ganglionic sympathetic fibres

TESTIS



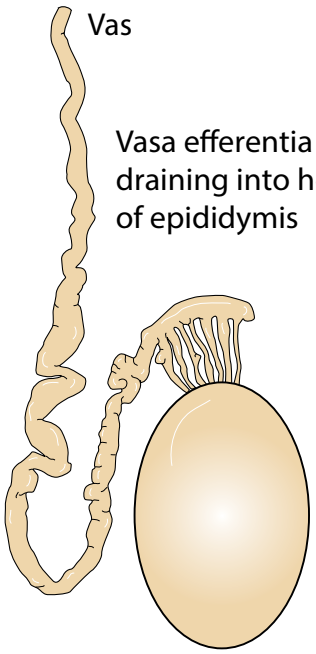
Left usually lies lower than right
Layers: Skin, dartos, Colles fascia, 3 layers of spermatic fascia, tunica vaginalis
Arteries: Testicular, cremasteric, artery to vas
Veins: Pampiniform plexus, testicular vein
Nerves: Sympathetic only for vasoconstriction and pain
Lymphatics: To para-aortics nodes
Descent: Testosterone, genitofemoral nerve and calcitonin gene related peptide

TORSION OF TESTIS



When the attachments of the testis within the tunica vaginalis is less than normal the testis hangs like a clapper in a bell and this allows it to twist. The blood supply is cut off and there is strangulation of the testis. This is then a surgical emergency to save the testis. When the delay is over 12 hours, the testis is usually lost. Such torsion is common around puberty, but can occur at any age. It is frequently associated with subsequent infertility.

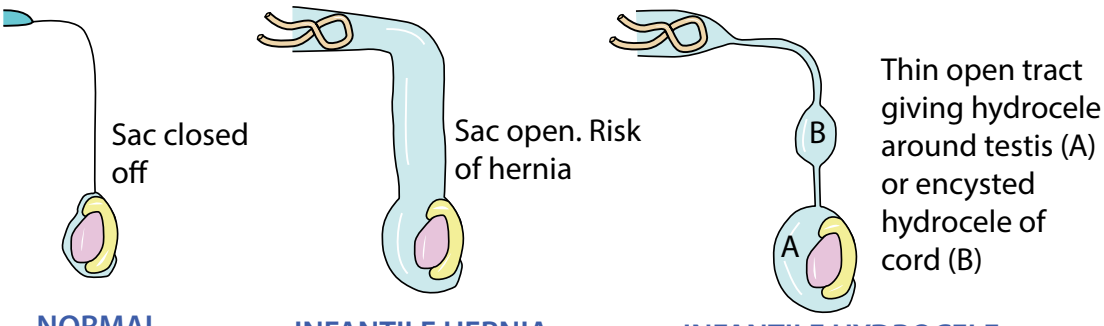
In neonates, the torsion is characteristically outside the tunica vaginalis and the twist involves the whole spermatic cord. The testis is usually not viable.



VAS DEFERENS

- 45cm long from epididymis to ejaculatory duct
- Has own artery from superior or inferior vesical artery
- Mesonephric (Wolffian) origin
- Ciliated epithelium
- **Nerve supply:** To testis and epididymis. Sympathetics from chain at L2 for vasoconstriction and carrying general visceral afferents for pain to T10 dermatome. NO parasympathetic

PATENT PROCESSUS VAGINALIS IN CHILDREN



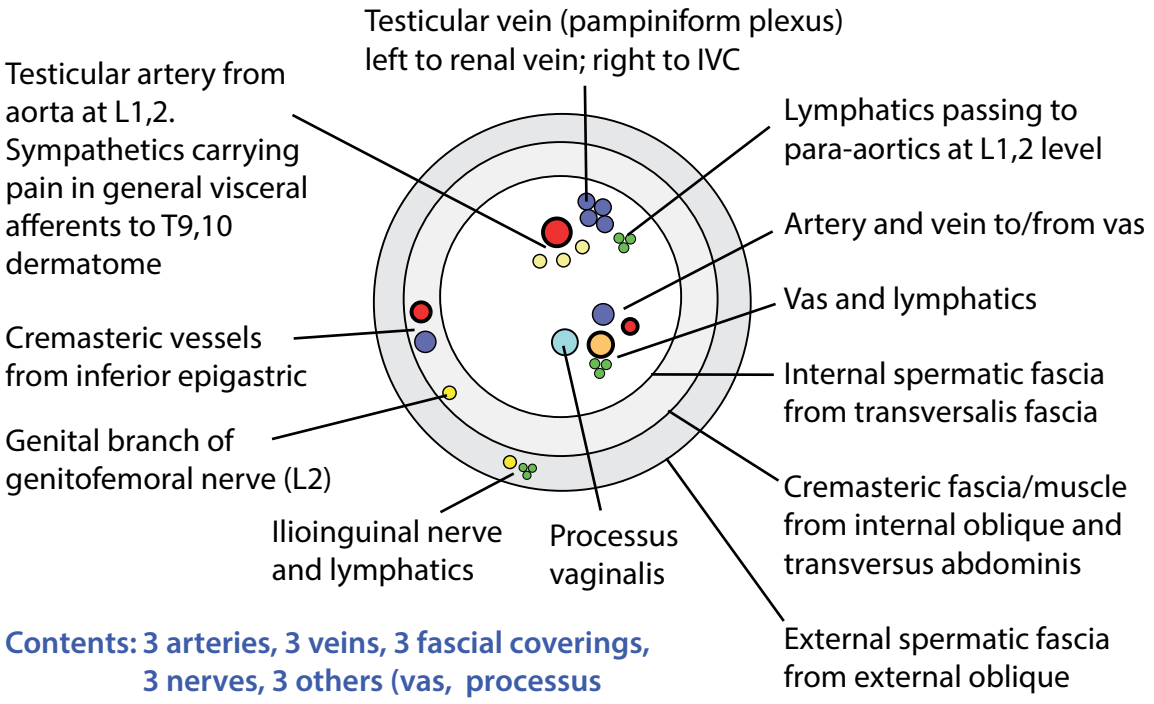
DESCENT OF THE TESTIS

FIRST 7 MONTHS:
Under hormonal control
LAST 2 MONTHS:
Controlled by genitofemoral nerve

Cell bodies of genitofemoral nerve in males contain Calitonin Gene Related Peptide (CGRP) which acts on the gubernaculum to give rhythmic contraction

SPERMATIC CORD

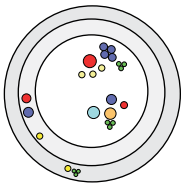
(Cross section just beyond external inguinal ring)



Contents: 3 arteries, 3 veins, 3 fascial coverings, 3 nerves, 3 others (vas, processus vaginalis, lymphatics)

SPERMATIC CORD

Contents of cord at 3 levels



VIA THE DEEP INGUINAL RING

- Vas
- Artery to vas (from superior or inferior vesical artery)
- Testicular artery (direct from aorta)
- Cremasteric artery (from inferior epigastric) artery
- Cremasteric vein (to inferior epigastric vein)
- Testicular vein (to IVC and left renal vein)
- Obliterated processus vaginalis
- Lymphatics
- Sympathetics
- Genital branch of genitofemoral nerve (L2). Motor to cremaster, sensory to fascia, tunica, scrotal skin, round ligament and labia majus

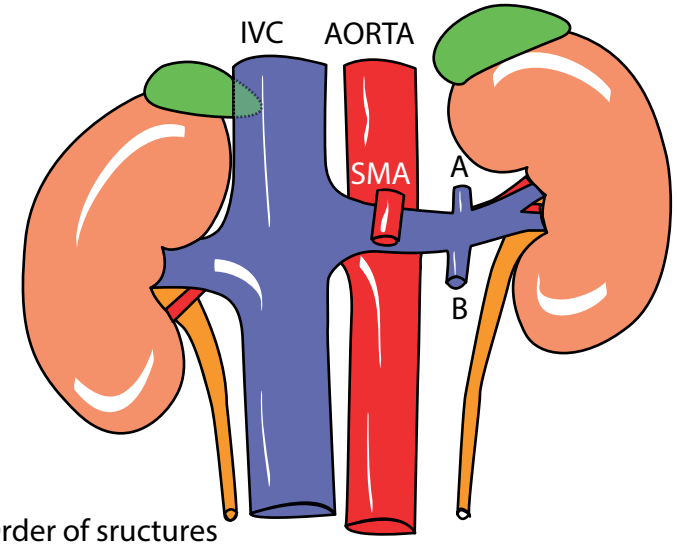
IN CANAL

- All these plus
- Internal spermatic fascia
- Cremasteric fascia
- Cremaster muscle
- Ilio-inguinal nerve

OUTSIDE SUPERFICIAL RING

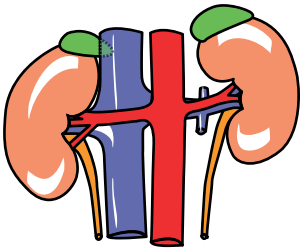
- All these plus
- External spermatic fascia from external oblique

RENAL VESSELS



Order of sructures at hilum anterior to posterior "V - A - U"

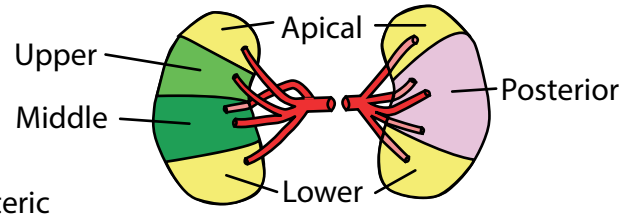
A = Left adrenal vein
B = Left gonadal vein
SMA = Superior mesenteric artery



Occasional arrangement with left renal vein passing posterior to aorta

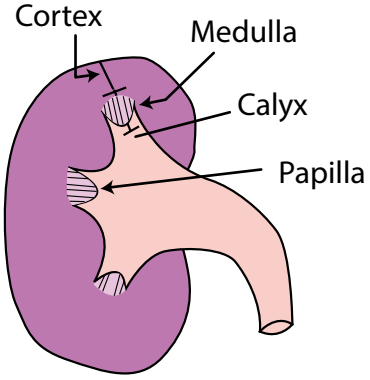
ANTERIOR VIEW

POSTERIOR VIEW



Segmental blood supply

KIDNEY - GENERAL



- 135g in female; 150g in male
- 11x6x3cm in adults
- 1200ml of blood per minute
- 1 million nephrons per kidney
- Lies retroperitoneal
- Moves 3 - 4cm on respiration
- Palpable lower pole in thin or young person
- Pelvis faces anteromedially
- Lymphatics to para-aortic nodes
- Sympathetics from T12-L1 for pain and vasoconstriction
- Parasympathetics from vagus. Function unknown
- Fetal kidney is lobulated
- Thin capsule. Easy to strip off in normal kidney
- Hila lie on transpyloric plane

Blood from renal artery

↓

Segmental arteries

↓

Lobar arteries
(to each pyramid)

↓

3 interlobar arteries
(junction of cortex and medulla)

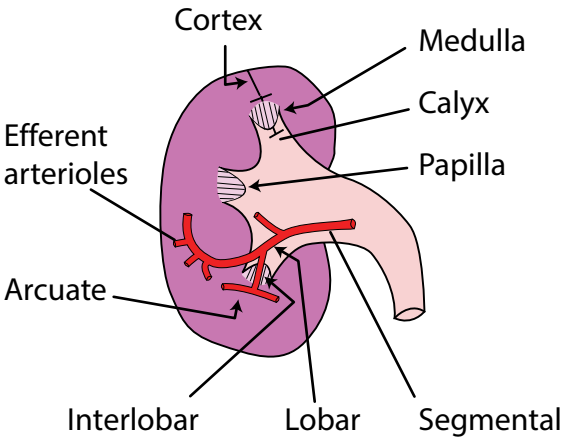
↓

Arcuate arteries
(running at right angles)

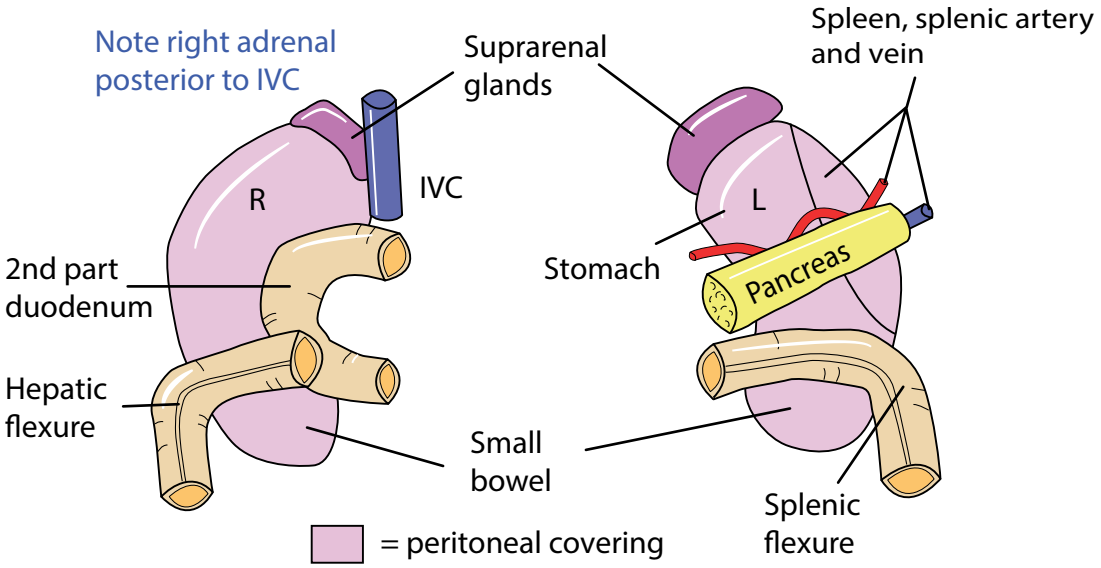
↓

Efferent arterioles
(to the cortex and glomeruli)

ARTERIAL SUPPLY OF KIDNEY

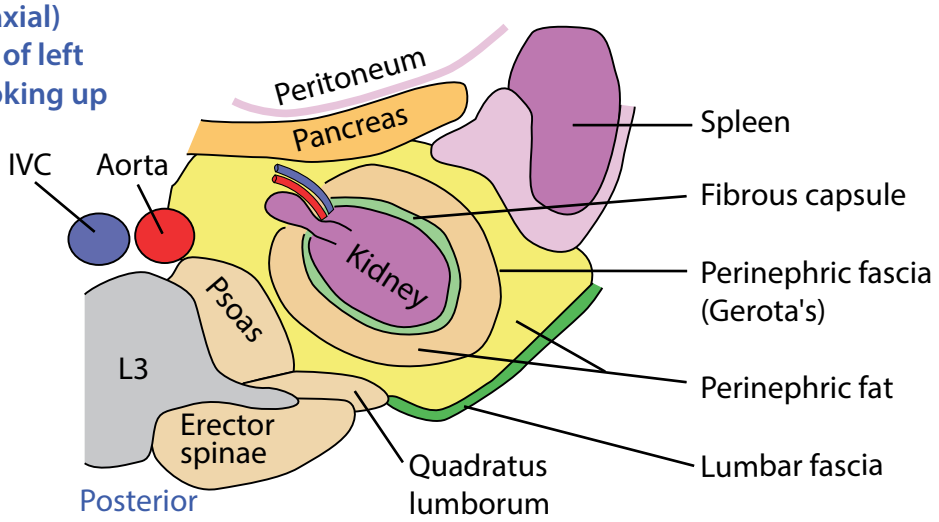


ANTERIOR RELATIONS OF KIDNEYS



KIDNEY - RELATIONS

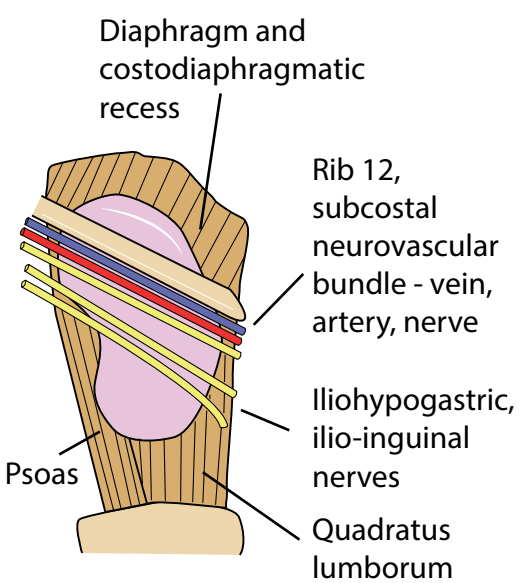
Cross (axial) section of left side looking up



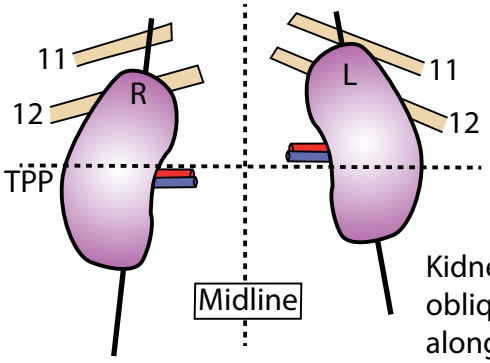
Note: The perinephric fascia is attached around the renal pelvis but is open inferiorly so that pus or extravasated urine can track down alongside the ureter.

Kidneys move 3-4cm on respiration

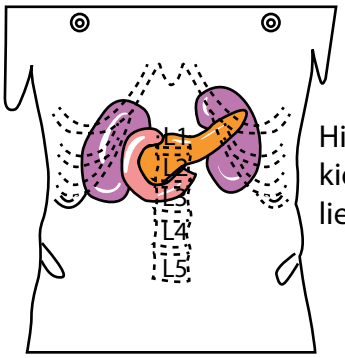
POSTERIOR RENAL RELATIONS



Both sides



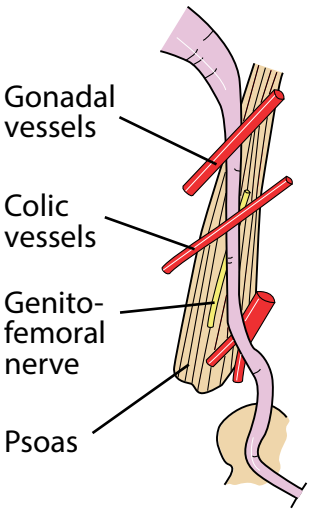
Kidney lies obliquely along line of psoas



Hila of kidneys lie on TPP

TPP = Transpyloric

URETER 1



25cm long. From renal pelvis to bladder. Smooth muscle and transitional urothelium

Posterior relations: Psoas, genitofemoral nerve, sacroiliac joint, common iliac artery bifurcation

Anterior relations: **Right**- Duodenum, right gonadal artery, right colic artery, ileal mesentery, superior mesenteric artery. **Left**- Left gonadal artery, left colic artery, sigmoid mesentery

Passes under: Vas, uterine artery

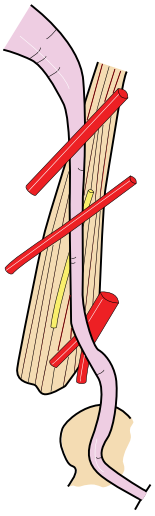
Related to: Lateral fornix of vagina in females

Blood supply: Renal, gonadal, vesical. Smaller branches from aorta, common iliac and vaginal arteries

Nerves: General visceral afferents for pain and sympathetics probably for vasoconstriction only

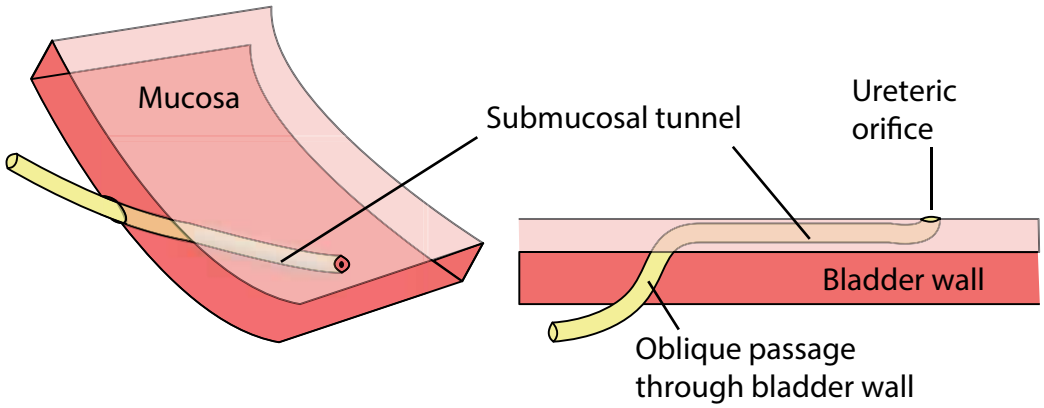
Points of potential hold up: Pelviureteric junction, pelvic brim, ureterovesical junction

URETER 2



- The ureter is recognisable as it shows peristalsis when pinched and is the most superficial retroperitonal structure in the pelvis adhering to the posterior surface of the peritoneum
- It crosses the bifurcation of the iliac arteries and then passes around the pelvis to 1cm short of the ischial spine before swinging medially
- On a plain abdominal X-ray it enters the bladder at the level of the pubic tubercle
- Right ureter may be irritated by an inflammed appendix
- Pain is referred progressively from loin to groin and tip of penis as a stone progresses down the ureter

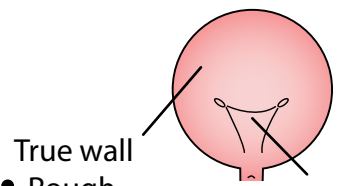
URETEROVESICAL JUNCTION



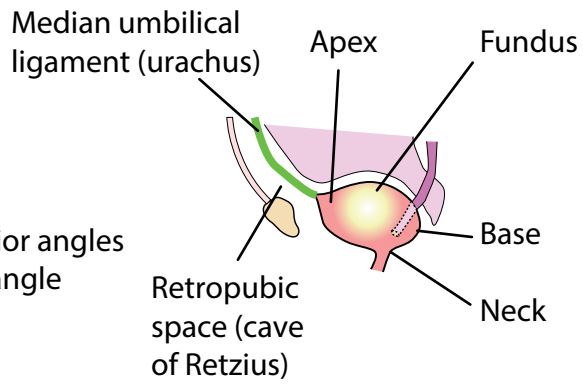
The ureter passes obliquely through the bladder wall then runs sub-mucosally for a distance that is 5 times the diameter of the ureter. This prevents vesico-ureteric reflux of urine

BLADDER - GENERAL

Epithelium: Transitional - watertight, stretchy, no glands. No peritoneum on anterior wall
Muscle: Detrusor, smooth muscle - 3 layers- inner/outer longitudinal, middle circular
Arteries: Superior/inferior vesical
Veins: Converge to vesicoprostatic plexus in males. Converge to plexus at base of broad ligament in female. Then to internal iliac veins
Lymphatics: Internal and external iliac nodes
Nerves: Sympathetic: Motor to bladder neck for closure at ejaculation, in males only. Inhibitory, vasomotor, pain in both sexes. Parasympathetic - motor to detrusor, sensory for full bladder, some pain

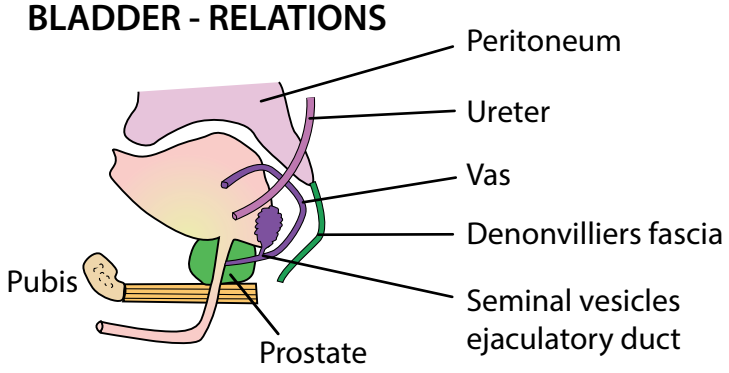


- Trigone, flat, triangular
- Ureteric orifices at superior angles
- Bladder neck at inferior angle
- Interureteric bar (2-5cm)

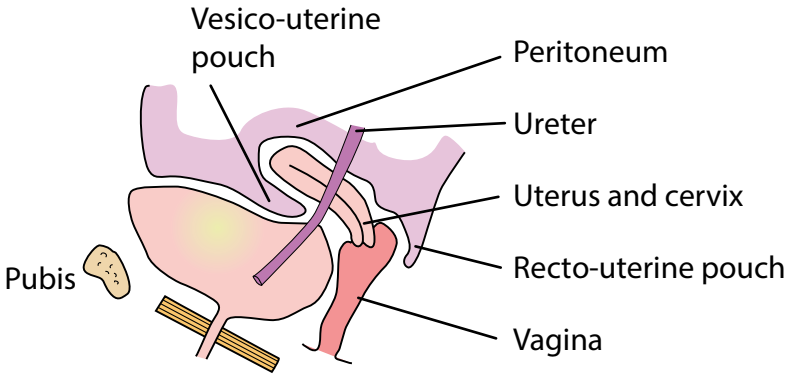


BLADDER - RELATIONS

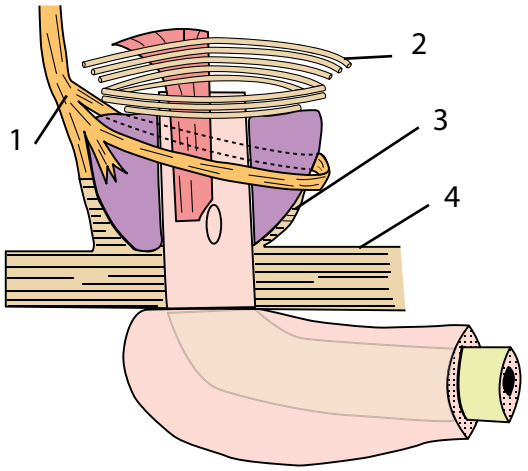
SAGITTAL VIEW OF MALE



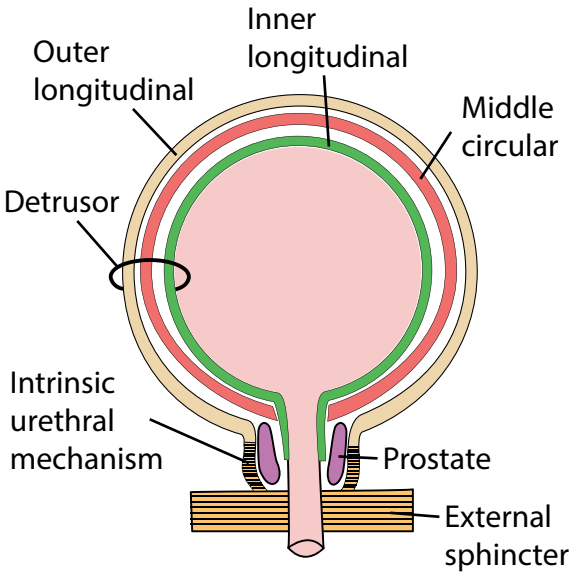
SAGITTAL VIEW OF FEMALE



BLADDER AND SPHINCTER MUSCLES

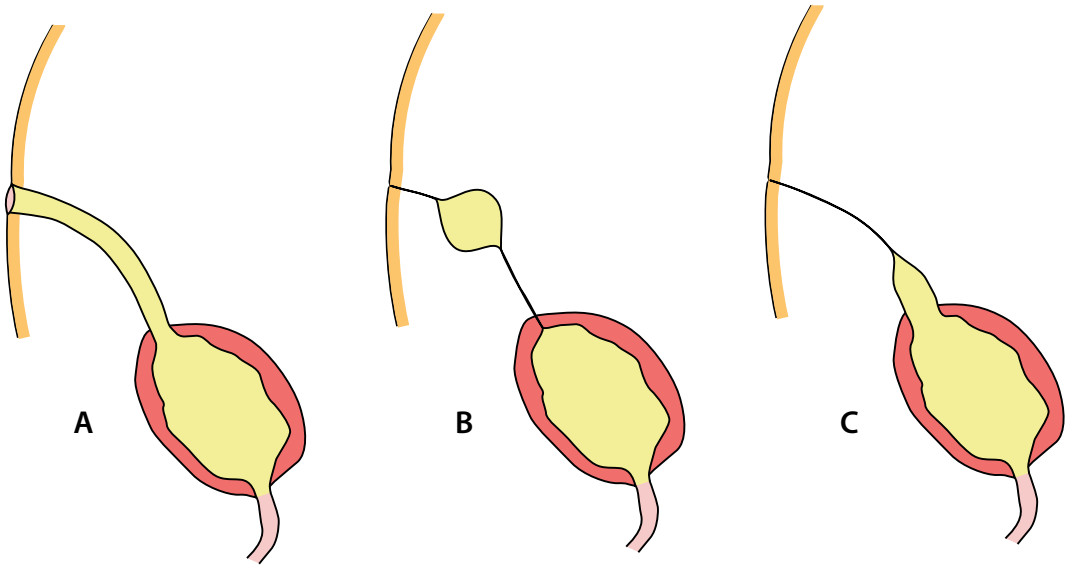


1. Longitudinal detrusor muscle
2. Circular muscle (bladder neck)
3. Intrinsic urethral mechanism
4. External voluntary sphincter



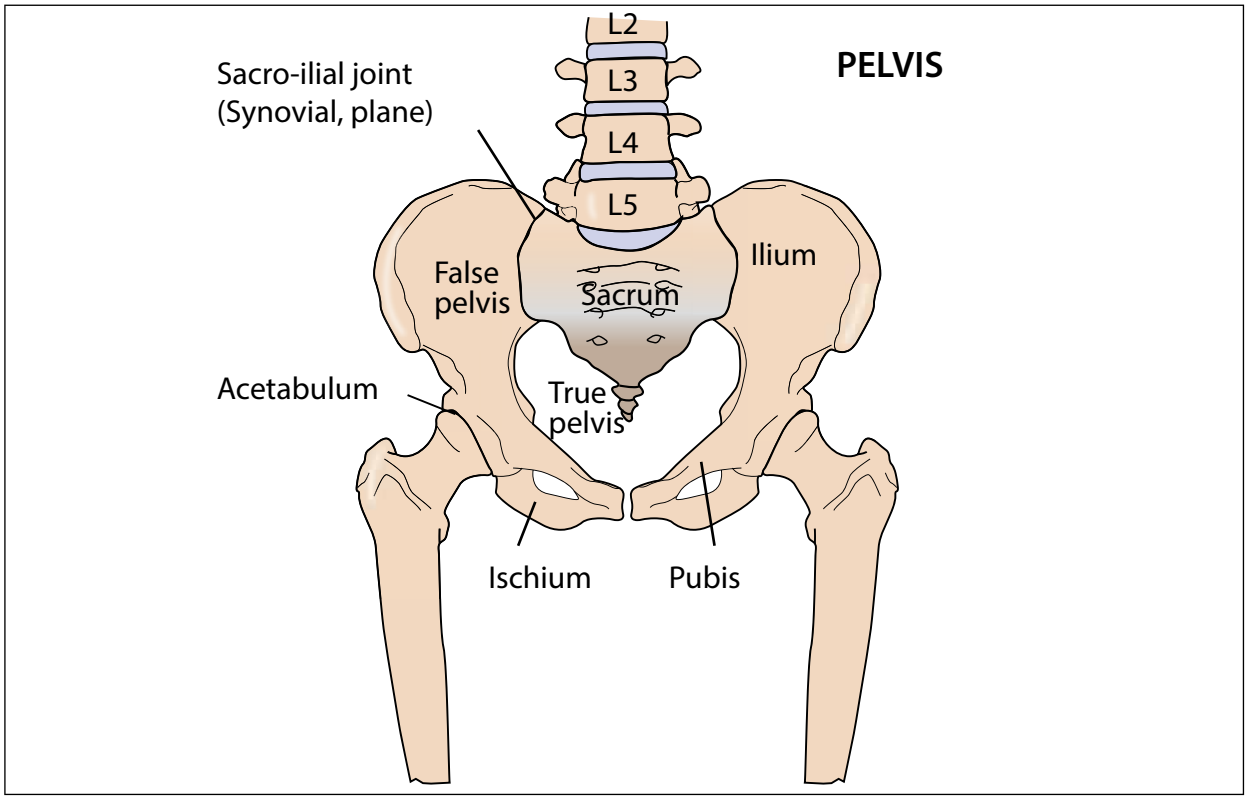
Note: The intrinsic urethral mechanism surrounds the prostatic capsule in the male and the urethra in the female. It is a blend of smooth muscle from the bladder and striated muscle from the external sphincter

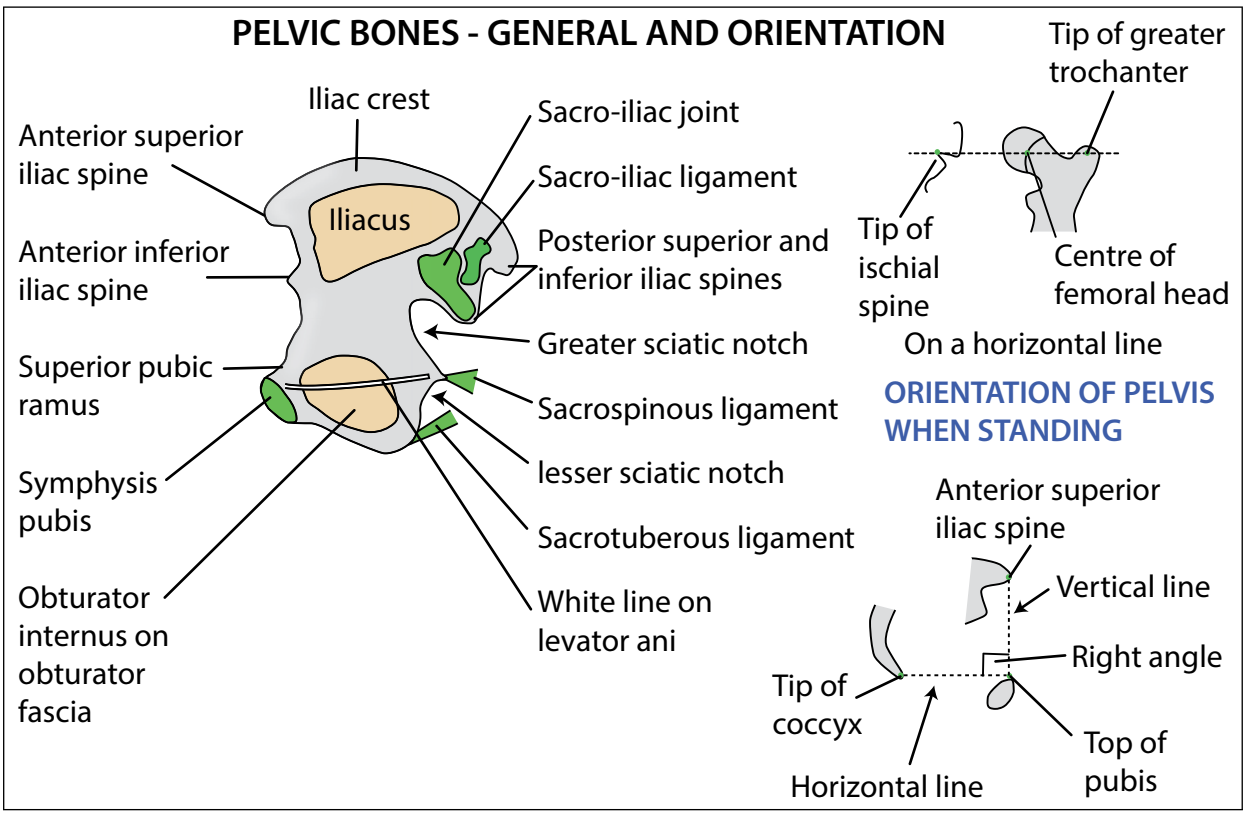
URACHAL DEFECTS



The urachus, which is a remnant of the allantois, may not close off correctly and it can either remain open with urine leakage (A) or form a cyst along it tract (B) or remain as a diverticulum of the bladder (C).

4.7 Pelvis and Perineum



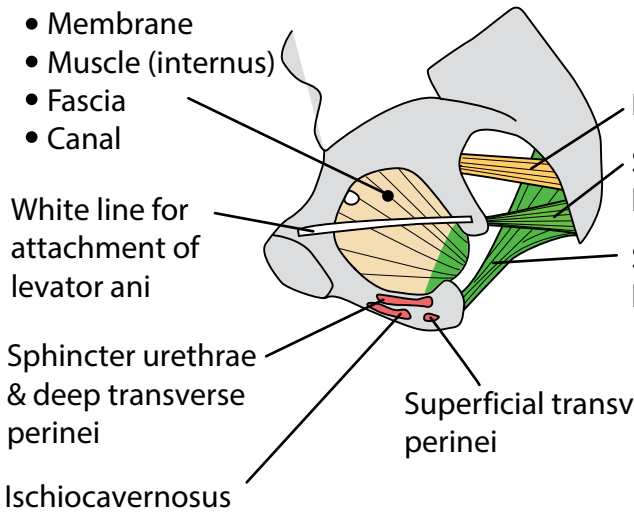


PELVIS - GENERAL

- True pelvis is below pelvic brim
- False pelvis is above pelvic brim

Obturator:

- Foramen
- Membrane
- Muscle (internus)
- Fascia
- Canal



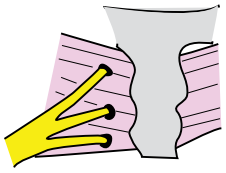
ANTERIOR WALL

- Symphysis pubis
- Body of pubis
- Pubic rami

LATERAL WALL

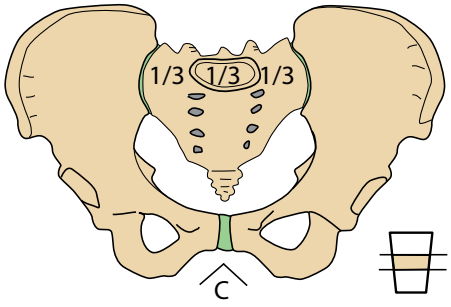
- Ilial, ischial, pubic rami
- Obturator membrane and internus muscle
- Sacrotuberous and sacrospinous ligaments
- Pelvic fascia
- Piriformis

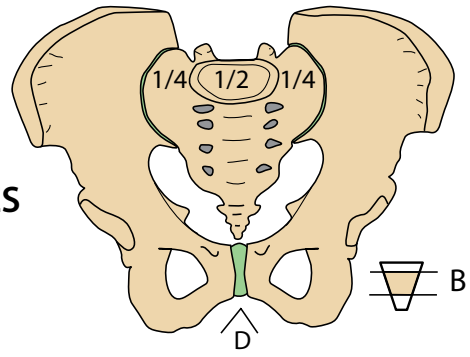
POSTERIOR WALL



- Sacrum
- Coccyx
- Piriformis
- Sacral plexus
- Sacral fascia

PELVIC BONES - SEX DIFFERENCES





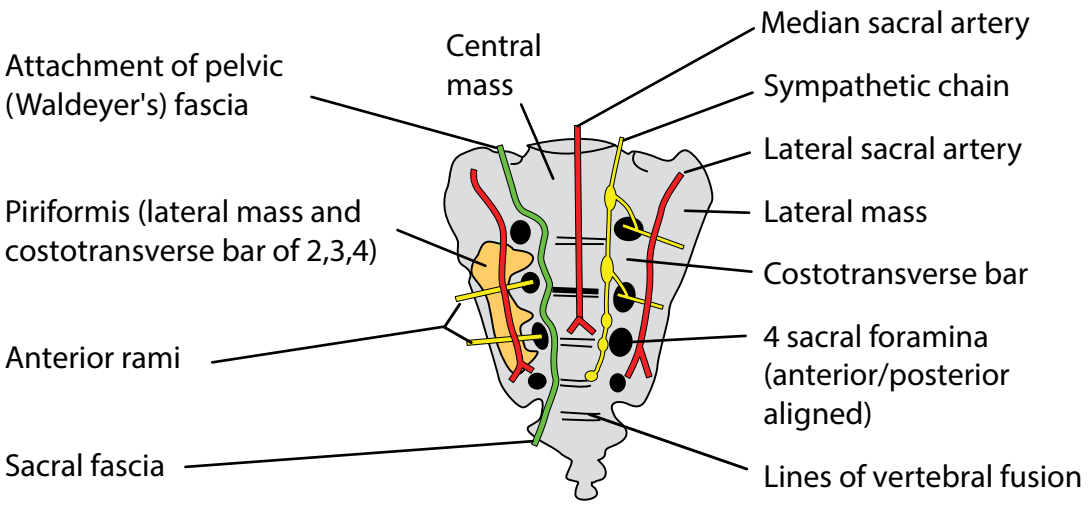
Female:

- Build - Less heavy
- Inlet rounded (gynaecoid)
- Short segment of long cone (A)
- Subpubic angle - >90 degrees (C)
- Obturator foramen - elongated/triangular
- Muscle markings +
- Wider between ischial spines
- Ratio between vertebral facet of sacrum and ala of sacrum 1/3, 1/3, 1/3
- Greater sciatic notch - nearly a right angle
- Ischiopubic ramus - smooth
- Pubic tubercle to acetabular margin V diameter of acetabulum - greater

Male:

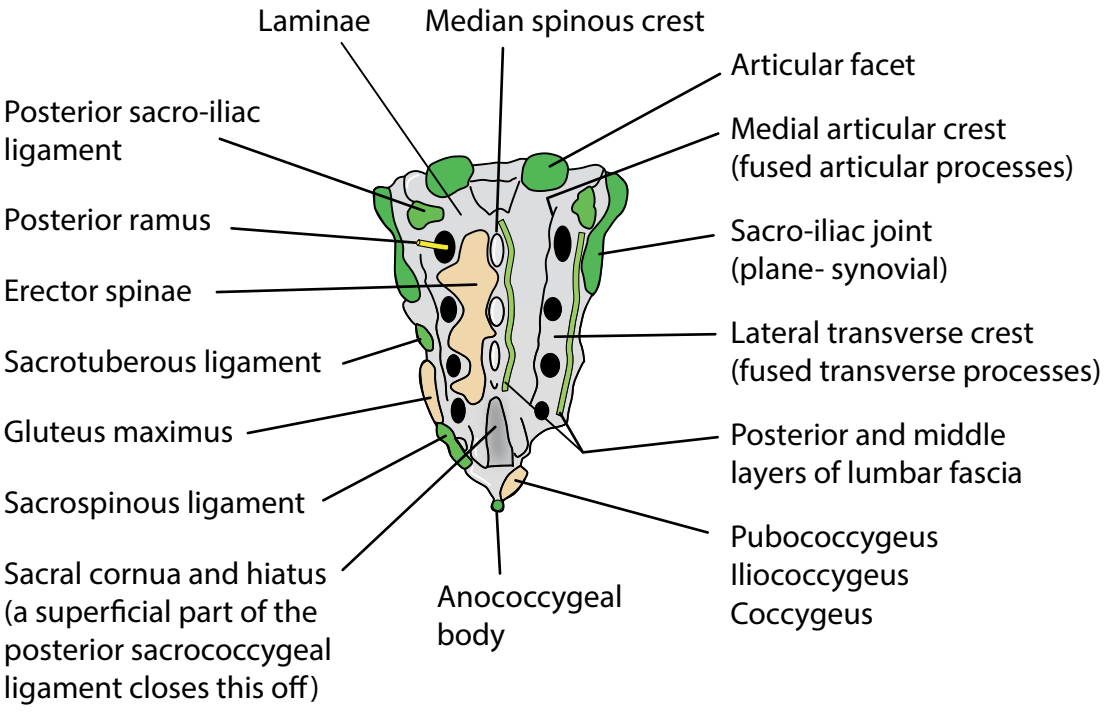
- Build - Heavy
- Inlet less rounded (android)
- Long segment of short cone (B)
- Subpubic angle - <90 degrees (D)
- Obturator fossa - rounded/oval
- Muscle markings +++
- Narrower between ischial spines
- Ratio between vertebral facet of sacrum and ala of sacrum 1/4, 1/2, 1/4
- Greater sciatic notch - less than a right angle (J shape)
- Ischiopubic ramus - rough (crura)
- Pubic tubercle to acetabular margin V diameter of acetabulum - equal or less

ANTERIOR SACRUM

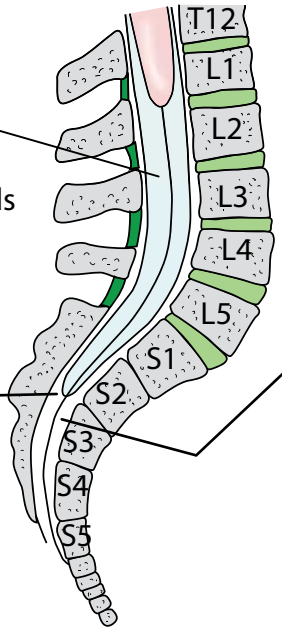


Order of structures from posterior to anterior is:
Bone, periosteum, piriformis, anterior ramus, pelvic fascia, lateral sacral artery, branches of iliac artery, ureter, peritoneum, bowel

SACRUM - POSTERIOR ATTACHMENTS



LATERAL SACRUM



Dural sac (subarachnoid space). It contains CSF, nerve roots and filum terminale (pia that extends to the coccyx)

End of dural sac (S2)

Spinal cord ends at lower border of L1

Extradural space below S2 with loose fat and veins. Used for caudal anaesthetic

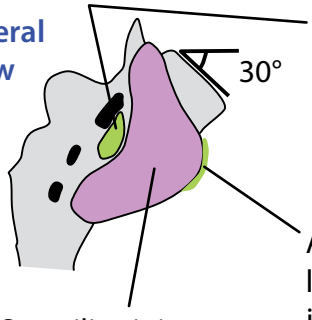
SACRAL DIMPLE INDICATES

- S2
- End of dural sac
- Posterior inferior iliac spine
  Mid sacro-iliac joint

SACRUM - GENERAL AND SACRO-ILIAC JOINT

- 5 fused vertebrae (may be 6 or 7)
- L5 may be sacralised
- Spina bifida occulta common
- Iliolumbar ligament from iliac crest to tip of 5th lumbar transverse process

Lateral view

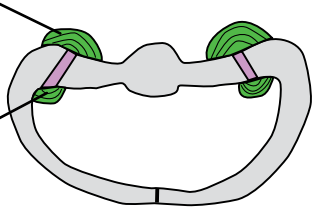


Posterior sacro- iliac ligament. strong ++

Anterior sacro- iliac ligament (thickening of joint capsule). Weakest of the ligaments

Sacroiliac joint jagged surfaces minimal movement but synovial

Viewed from above



All these ligament need to be strong to prevent sacrum sliding forwards

POSTERIOR ABDOMINAL WALL

- 5 vertebrae
- Transverse process of L3 is largest
- Transverse process of L5 is conical

PSOAS MAJOR

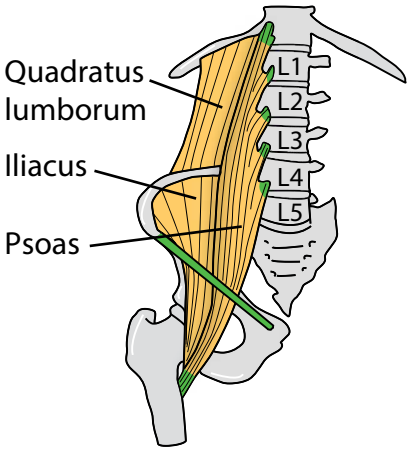
Origin: Intervertebral discs T12/L1 to L4/5, bodies of T12-L5, transverse processes L1-5
Inserts: Lesser trochanter
Nerve: L1,2
Action: Flexes hip

PSOAS MINOR (not shown)

Origin: Bodies T12, L1
Inserts: Fascia over psoas major behind inguinal ligament
Nerve: L1
Action: Weak spine flexor

ILIACUS

Origin: Hollow of iliac fossa
Inserts: Psoas tendon and lesser trochanter
Nerve: Femoral (L2,3)
Action: Flexes hip



QUADRATUS LUMBORUM

Origin: Inferior border of rib 12
Inserts: Transverse processes L1-4, iliolumbar ligament and posterior 1/3 iliac crest
Nerve: T12-L3
Action: Holds down 12th rib and aids lateral flexion of trunk

SACRAL PLEXUS
L4,5,S1,2,3,4,5

Lies on piriformis on posterior wall of pelvis, deep to the vessels and covered by parietal pelvic fascia

6 BRANCHES OFF THE SACRAL ROOTS BEFORE THEY DIVIDE INTO ANTERIOR AND POSTERIOR DIVISIONS

They all begin with the letter "P"

1. Posterior femoral cutaneous nerve (S1,2,3)
2. Pudendal nerve (S2,3,4)
   (1 and 2 - leave via greater sciatic foramen)
3. Perforating cutaneous nerve (S2,3)
   (3 - perforates sacrotuberous ligament)
4. Nerve to piriformis (S1,2)
5. Perineal branch of S4 (to levator ani)
6. Pelvic splanchnics (S2,3,4)
   Parasympathetic motor to bladder, hind gut, erection.
   Sensory for distension and pain from bladder, lower uterus, lower colon and rectum
   (4,5,6 - all remain in pelvis)

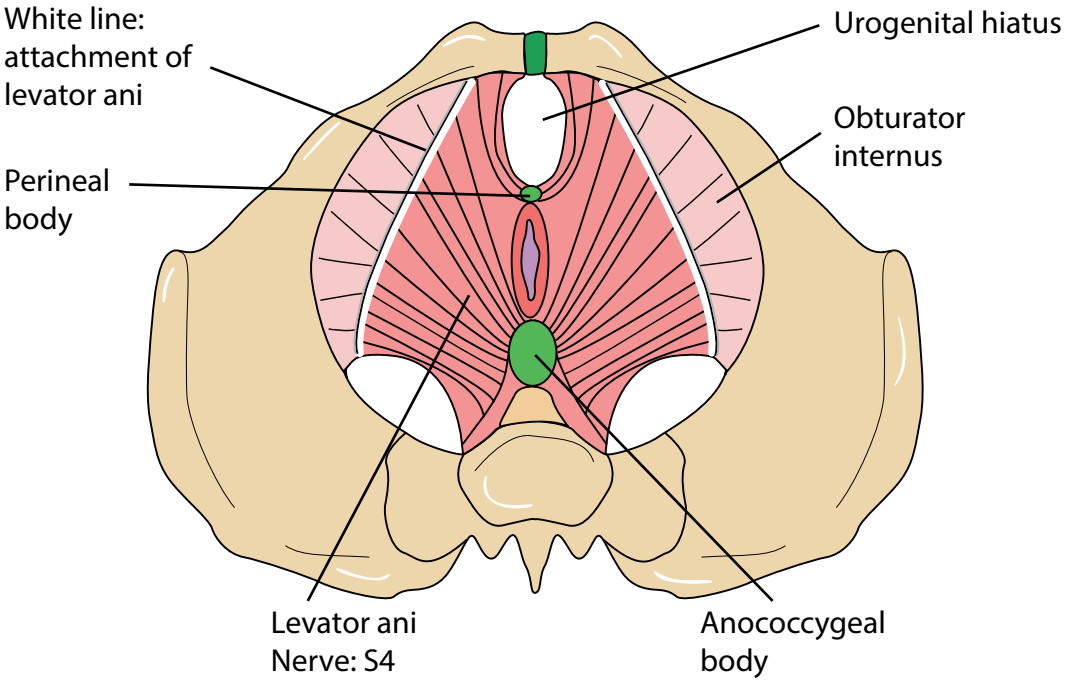
FROM ANTERIOR DIVISONS

- Nerve to quadratus femoris (L4,5,S1)
- Nerve to obturator internus (L5,S1,2)
- Tibial portion of sciatic nerve (L4,5,S1,2,3)
  (see sciatic nerve in lower limb section)

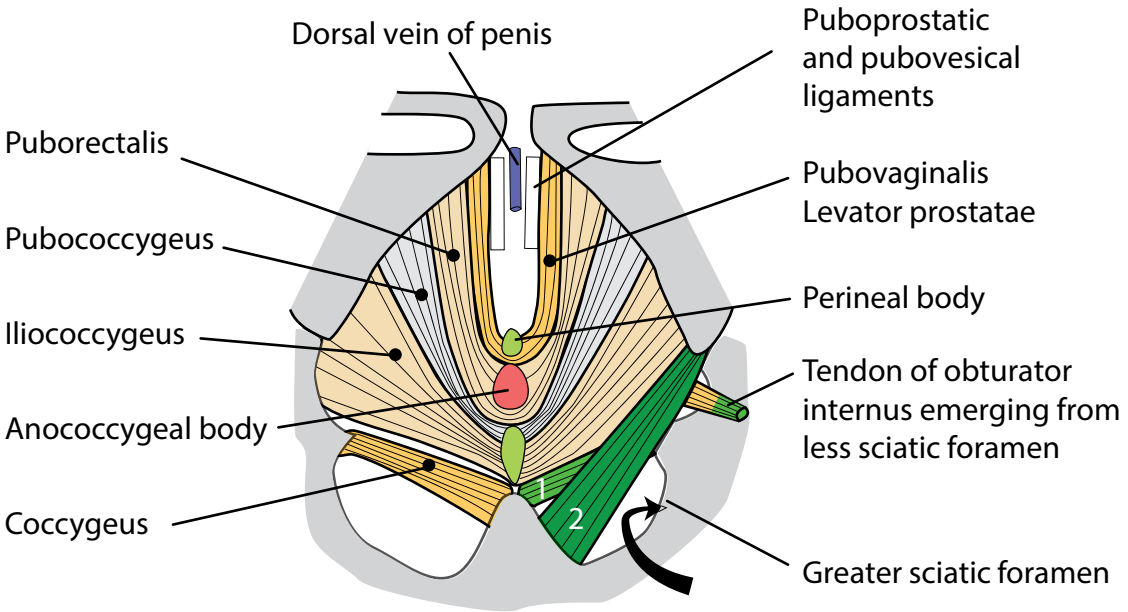
FROM POSTERIOR DIVISIONS

- Superior gluteal (L4,5,S1)
- Inferior gluteal (L5,S1,2)
- Common fibular portion of sciatic nerve (L4,5,S1,2)
  (see sciatic nerve in lower limb section)

PELVIC FLOOR FROM ABOVE



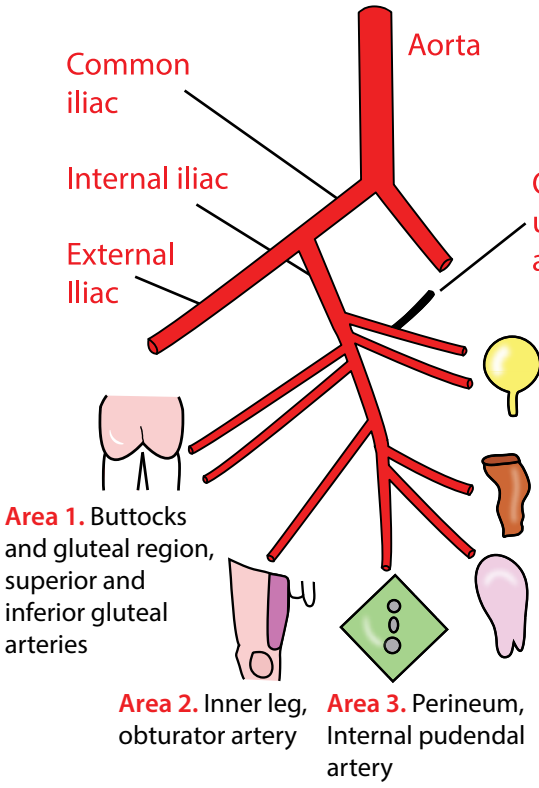
PELVIC FLOOR FROM BELOW



- Covered superiorly and inferiorly with fascia (epimysium)
- Nerve supply for levator ani is perineal branch of S4. S5 for coccygeus

1= Sacrospinous ligament
2= Sacrotuberous ligament

BRANCHES OF THE INTERNAL ILIAC ARTERY



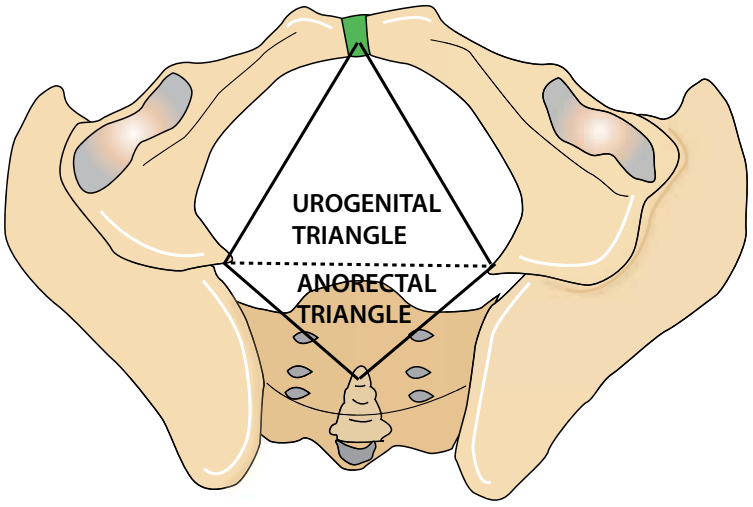
An easy way to remember branches:

2 groups each with 3 branches

Group 1 ORGANS
1. Bladder
2. Rectum
3. Uterus

Group 2 AREAS
1. Buttocks/gluteal
2. Adductor compartment
3. Perineum

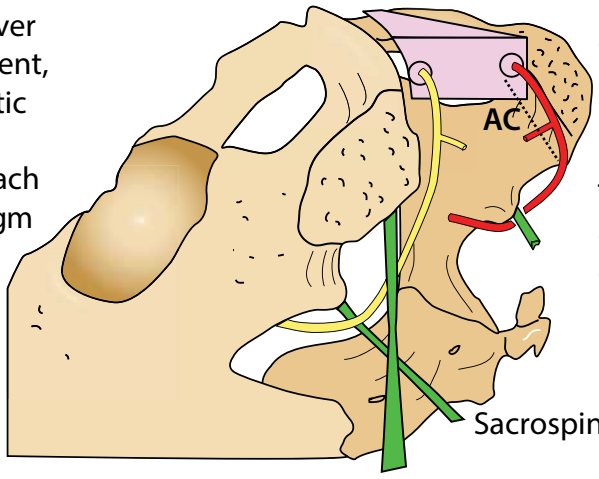
DEFINITION OF THE PERINEUM



The perineum is that part of the trunk distal to the pelvic diaphragm.
It is 2 triangles lying at nearly a right angle to each other:
Urogenital - covered in below with urogenital diaphragm
Anal - covered only with skin, fascia and gluteus maximus when standing up

SACROTUBEROUS AND SACROSPINOUS LIGAMENTS AND UROGENITAL DIAPHRAGM

Pudendal nerve exiting via greater sciatic foramen, passing over sacrospinous ligament, entering lesser sciatic foramen, then into Alcock's canal to reach urogenital diaphragm



Internal pudendal artery exiting from greater sciatic foramen, over ischial spine and entering lesser sciatic foramen. Then running in Alcock's canal to reach urogenital diaphragm

Nerve and artery give off inferior rectal branches in Alcock's canal (AC)

MALE PERINEUM

Transverse perineal ligament (anterior edge of urogenital diaphragm)

Inferior (arcuate) pubic ligament

Bulbospongiosus: perineal body and median raphe to perineal membrane)

Ischiocavernosus: inferior ischiopubic ramus and perineal membrane surrounding corpus cavernosum

Deep transverse perinei: between ischiopubic rami and pubic body

Cut crus

Superficial transverse perinei: ischial tuberosity to perineal body

Perineal membrane (inferior layer of urogenital diaphragm)

Levator ani

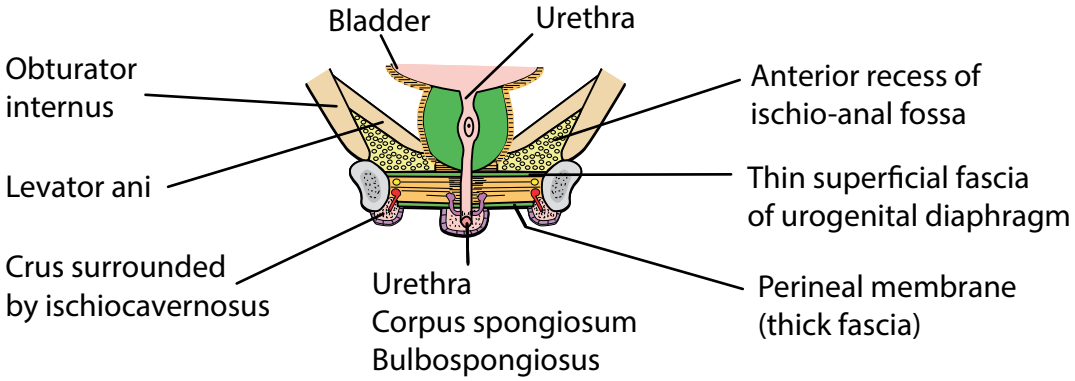
Perineal body (central perineal tendon)

Anococcygeal body

Subcutaneous anal sphincter

MALE PERINEUM - DEEP PERINEAL POUCH

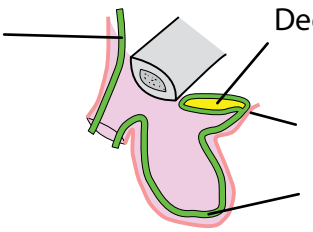
Deep perineal pouch (between perineal membrane and superior fascia of urogenital diaphragm).
Contains: Membranous urethra, deep transverse perinei, external urethral sphincter, bulbourethral (Cowper's) glands which drain into urethra below the perineal membrane, internal pudendal vessels, dorsal nerve of penis
Note: The external sphincter has striated muscle extensions around lower prostatic urethra, above the urogenital diaphragm, that mix with smooth bladder wall muscle and are called the **intrinsic urethral mechanism**



Coronal section through urogenital diaphragm at level of the prostate

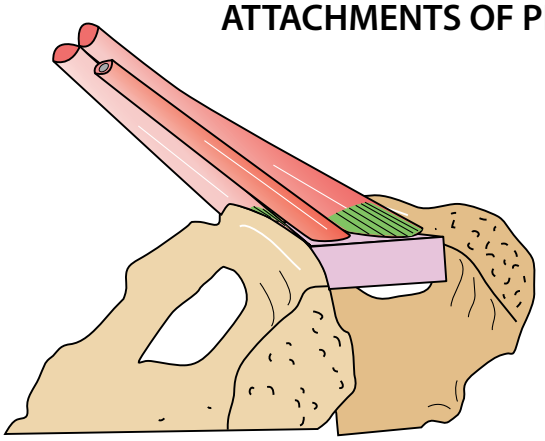
MALE SUPERFICIAL PERINEAL POUCH

Scarpa's fascia is fused to the pubis then extends into the scrotum as Colles' fascia and around the penis as Buck's fascia



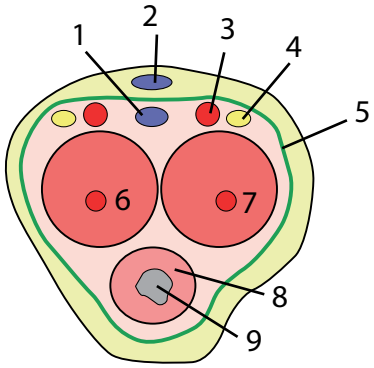
Superficial perineal pouch: Contains all perineal structures below perineal membrane: 2 crura with ischiocavernosus muscles around them. Distal urethra with corpus spongiosum around it. Bulbospongiosus muscle around bulb. Superficial transverse perinei muscles, perineal body, perineal branches of internal pudendal artery, pudendal nerve and branches, Colles' fascia, ducts of Cowper's glands, deep and superficial external pudendal arteries, spermatic cords, testes, penis, dartos muscle (panniculus carnosus of animals), branches of ilio-inguinal and genitofemoral nerves
Scrotal blood supply: Deep and superficial external pudendal arteries, branches of internal pudendal arteries. Veins to external pudendal
Nerves to scrotum: Anterior 1/3 - ilio-inguinal; posterior 2/3 - posterior scrotal branches of perineal nerve and perineal branches of posterior femoral cutaneous nerve
Lymph: Superficial inguinal glands

ATTACHMENTS OF PENIS



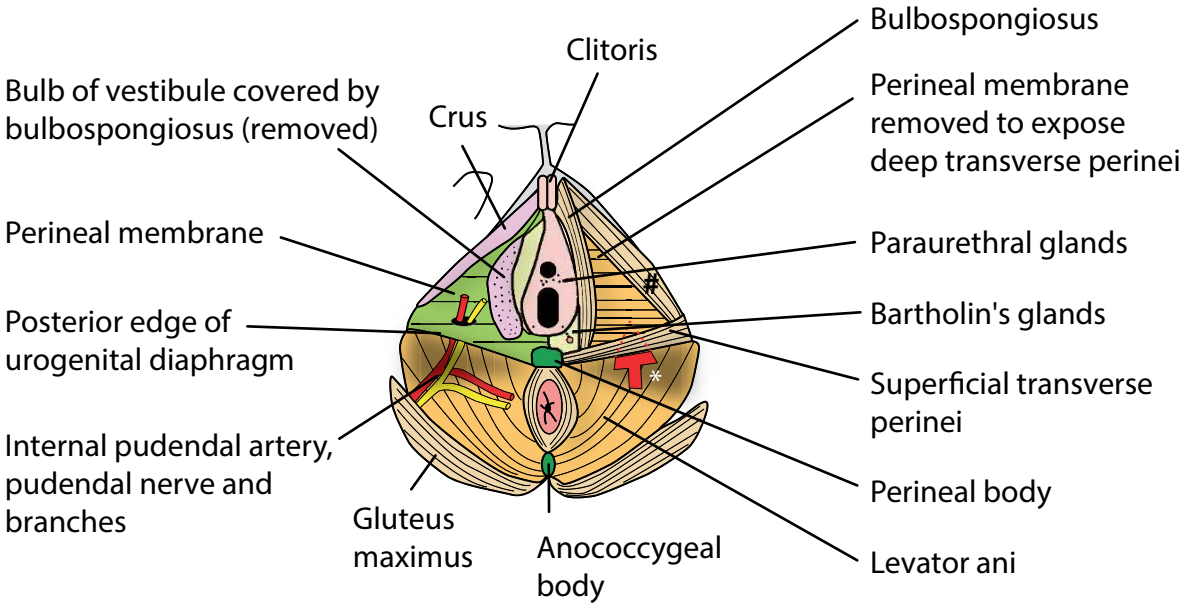
This inferior view of the urogenital diaphragm (purple) in a male shows attachments of crura of penis to ischiopubic rami on each side and urethra joining them to complete the structure of penis (right).

CROSS SECTION



1 Deep dorsal vein of penis
2 Superficial dorsal vein of penis
3 Dorsal artery of penis
4 Dorsal nerve of penis
5 Buck's fascia
6 Corpus cavernosum
7 Deep artery of penis
8 Corpus spongiosum
9 Urethra

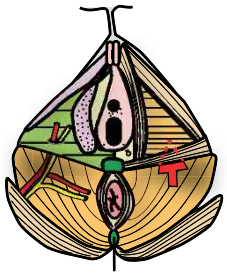
FEMALE PERINEUM



Ischiocavernosus overlying crus

* Arrow indicates anterior recess of ischioanal fossa

FEMALE PERINEUM - GENERAL



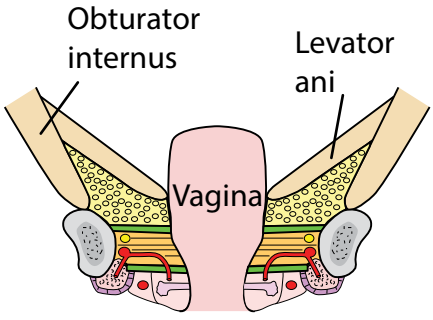
Greater vestibular glands (Bartholin)
Round (<1cm) glands at 4 and 8 o'clock behind bulb. 2cm duct into posterolateral vaginal orifice. In superficial perineal pouch. Homologues of Cowper's glands in males. Cysts and infection possible

Paraurethral glands (Skene)
Mucous glands opening just inside urethra. Homologue of prostate

Lesser vestibular glands
Not shown. Multiple small mucous glands opening between vagina and urethra

Labia majora - joined back and front by anterior and posterior commissures. Round ligament of uterus ends anterior end of each. **labia minora** give clitoral prepuce. **Clitoris** - 2 small corpora cavernosa. **Bulb** - spongy erectile tissue in labia minora

FEMALE PERINEUM VESSELS AND POUCHES



Coronal section through urogenital diaphragm at level of vagina

Deep perineal pouch (between perineal membrane inferiorly and the superior fascia of urogenital diaphragm superiorly)

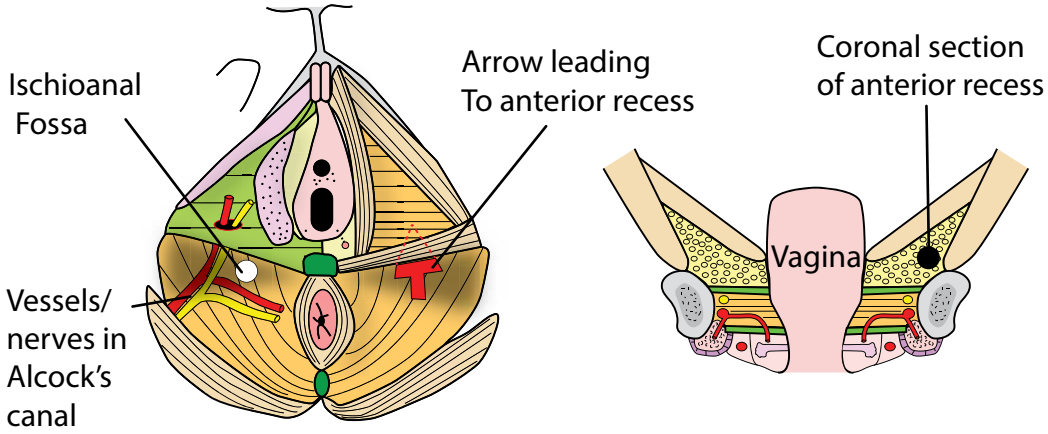
- Vagina
- Urethra
- Sphincter urethrae
- Deep tranverse perinei
- Dorsal nerve of clitoris
- Dorsal/deep clitoral arteries

Superficial perineal pouch
(everything inferior to perineal membrane)

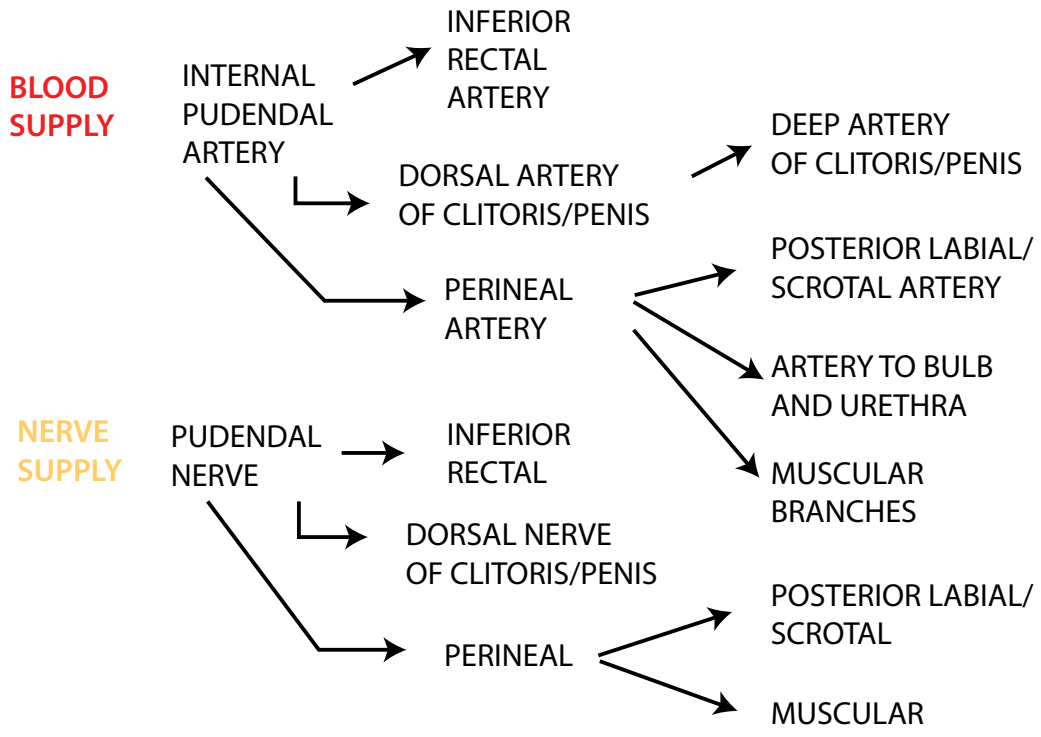
- 2 crura of clitoris
- Bulb and bulbospongiosus
- Superficial transverse perinei
- Perineal body
- Perineal artery/nerve/branches
- Vestibular glands

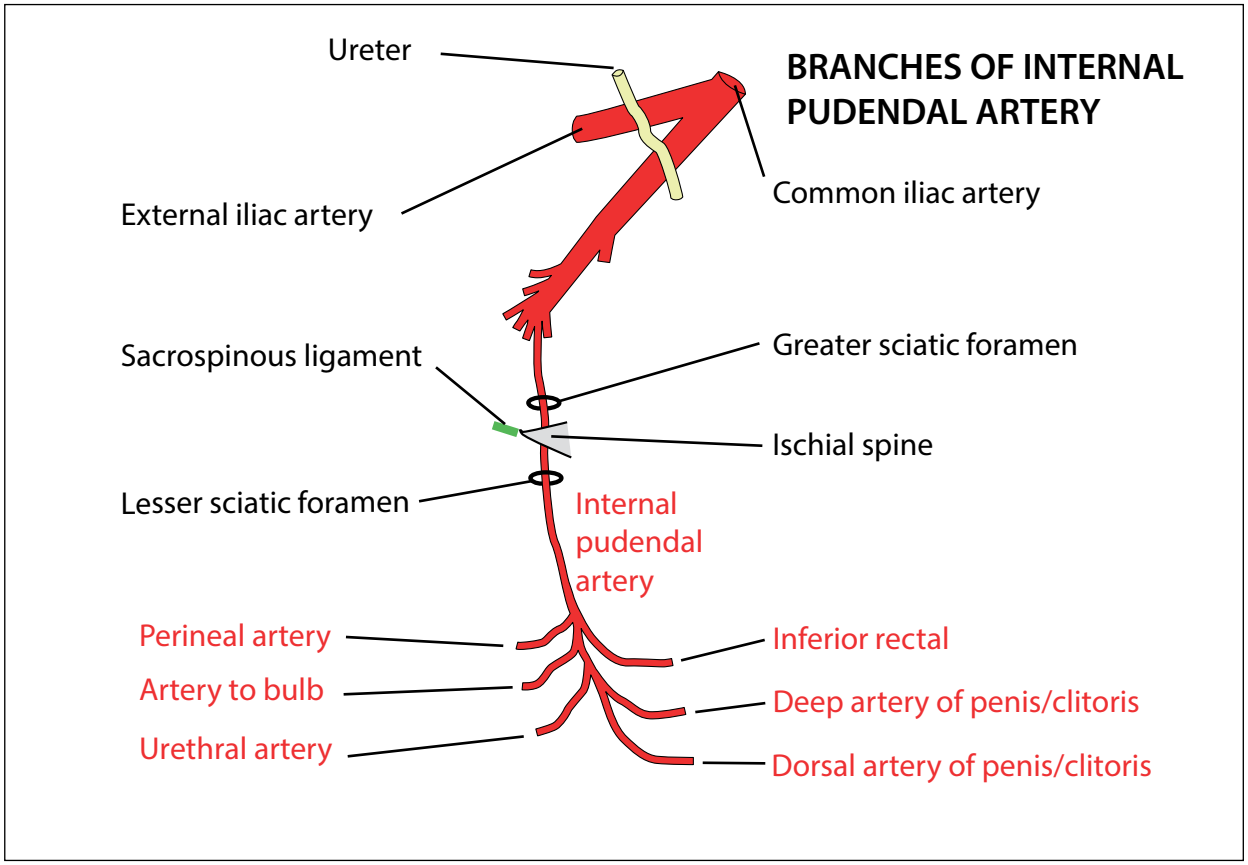
ISCHIOANAL (ISCHIORECTAL) FOSSA

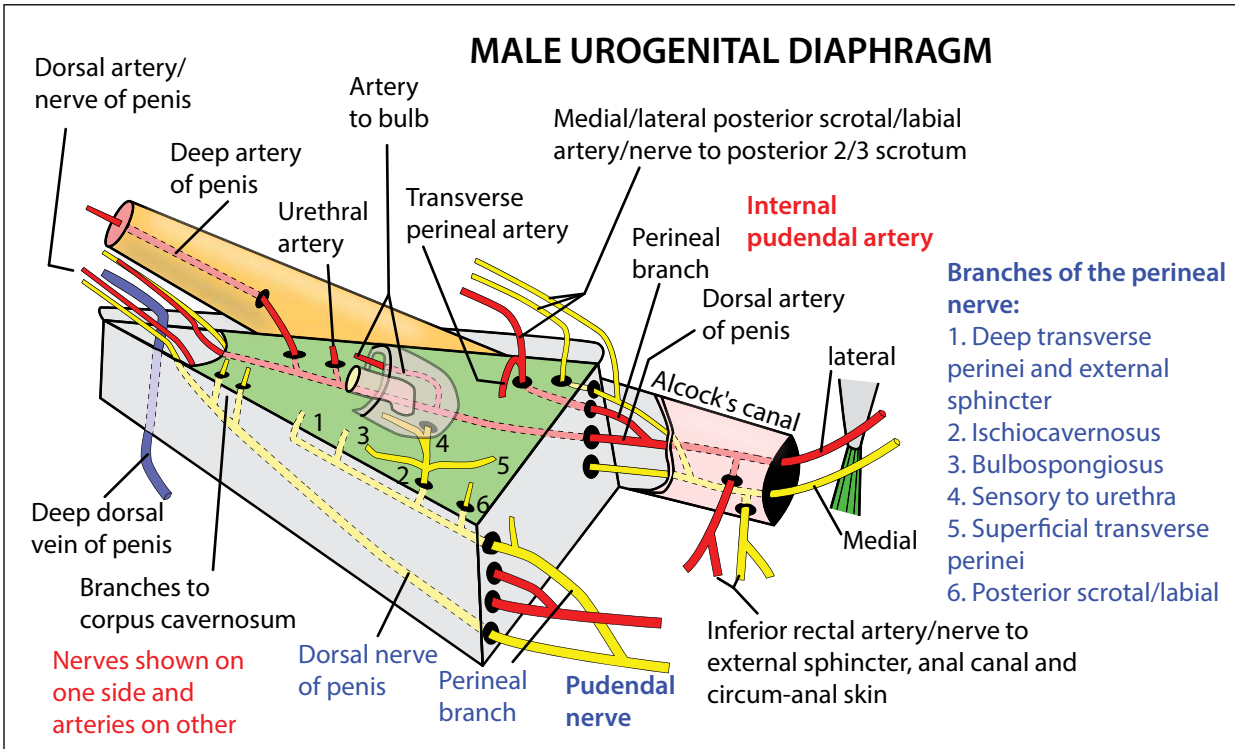
Wedge shaped space filled with fat; Crossed by inferior rectal nerve and artery; Alcock's canal in its lateral wall; **Base:** Perineal skin; **Medial:** Anal canal, levator ani; **Lateral:** Ischial tuberosity, obturator internus; **Apex:** White line; **Anterior:** Perineal body, urogenital diaphragm, anterior recess; **Posterior:** Posterior recess, gluteus maximus, sacrotuberous ligament, anococcygeal body, horseshoe connection; **Contains:** Fat, Alcock's (pudendal) canal, internal pudendal artery, pudendal nerve, inferior rectal artery/nerve, perineal branch of S4, perforating cutaneous nerve



VESSELS AND NERVES OF THE PERINEUM







This complicated image is designed to help with understanding details of the

4.8 Referred Pain and Autonomics

REFERRED PAIN

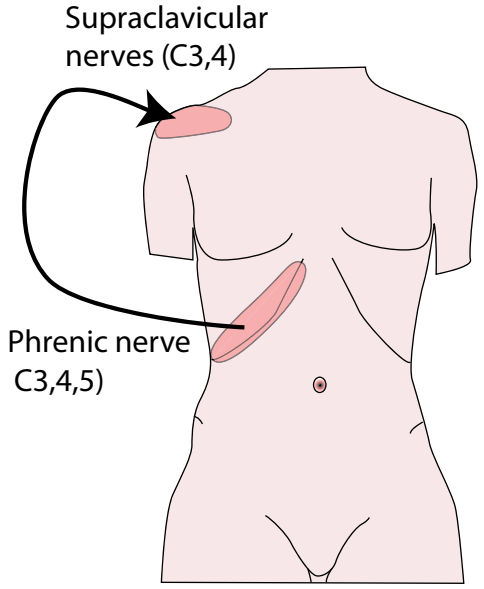
Pain generated in one site
and felt in another

TYPES OF REFERRED PAIN

1. SOMATIC TO SOMATIC
Involving somatic nerves only with no autonomic involvement.
2. PRESSURE OR TRAUMA TO NERVES
Involving somatic nerves only with no autonomic involvement.
3. GENERAL VISCERAL AFFERENT (GVA)
Pain from visceral organs (intestine, heart, etc.). GVAs detect ischaemia, distension and inflammation and travel mostly in sympathetic nerves throughout the thorax and abdomen and probably with parasympathetics from organs of cloacal origin (bladder, rectum, lower vagina)

SOMATIC TO SOMATIC REFERRED PAIN

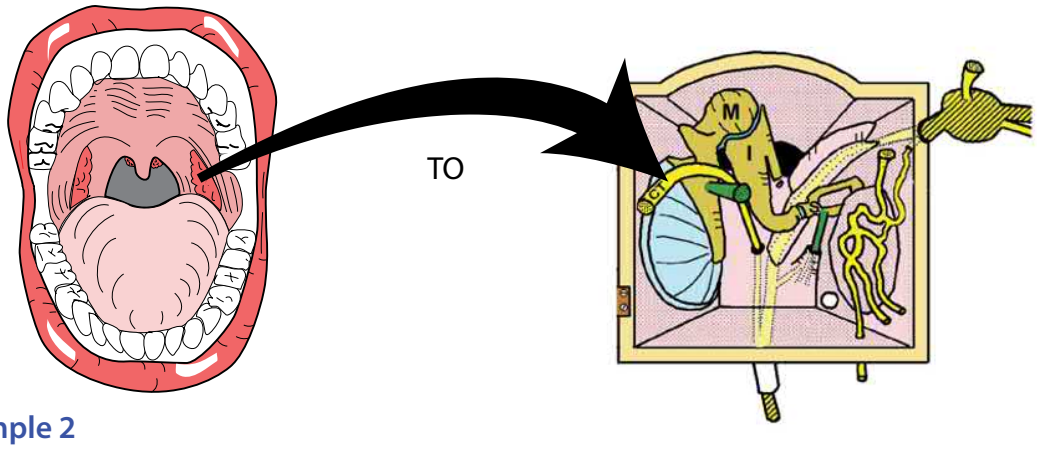
Example 1
Somatic pain detected by the phrenic nerve (C3,4,5) supplying the peritoneum on the under surface of the diaphragm from, say, an inflammed gallbladder, refers the pain to the dermatomes C3,4,5 (mostly C4) which supply the skin over the shoulder in the same side via the supraclavicular nerves from the cervical plexus.
This is explained by the descent of the septum transversum from a cephalad position to form the diaphragm and taking its nerve supply with it.



SOMATIC TO SOMATIC REFERRED PAIN

TONSIL
Glossopharyngeal (IX)
in oropharynx

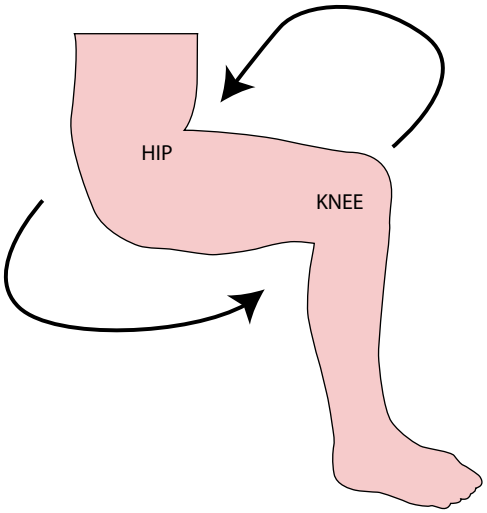
MIDDLE EAR
Glossopharyngeal (IX)
tympanic branch



Example 2

The oropharynx and the palatine tonsil within it is supplied by the glossopharyngeal nerve (IX). Pain from the tonsil or tonsillar bed, for instance after a tonsillectomy, is referred to the middle ear which is also supplied by the glossopharyngeal nerve via its tympanic branch. There is no autonomic involvement.

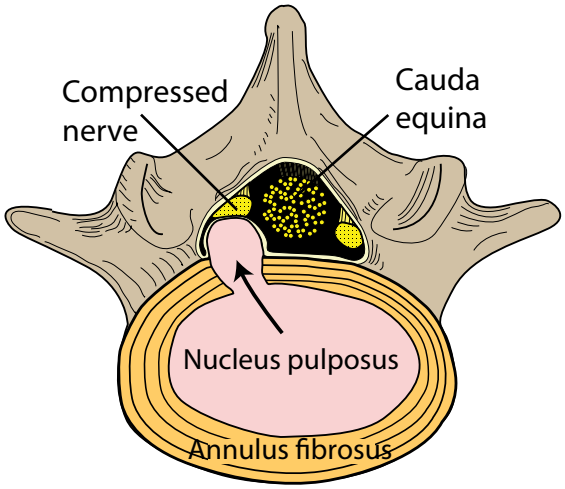
SOMATIC TO SOMATIC REFERRED PAIN



Example 3

Hilton's Law states that the sensory nerve supply of a joint is the same as the nerve supply of the muscles that move it. The obturator nerve thus supplies both the hip and the knee. In small children who stop weight bearing the pain could be arising in either joint and the clinician should be aware of this.

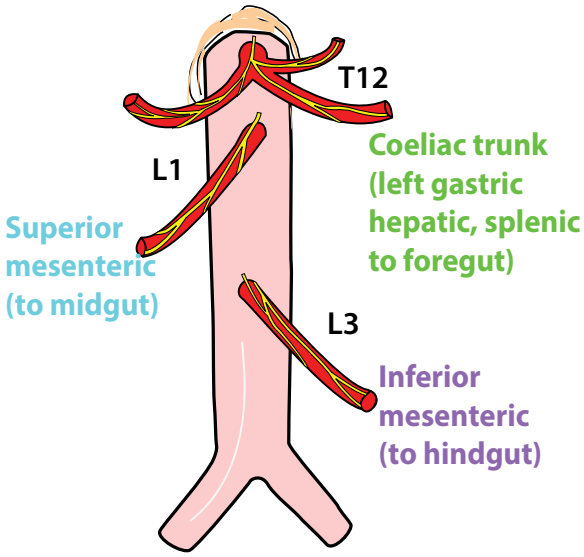
DIRECT PRESSURE ON A NERVE

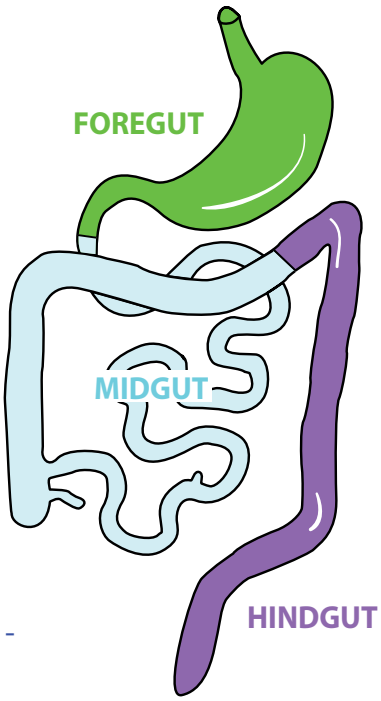


Example

Pressure from a prolapsed disc in the lumbar region gives local pain but also referred pain to the lower limb. Another example is pressure on a nerve in the cervical region giving pain in the upper limb. The autonomic nerves are not involved.

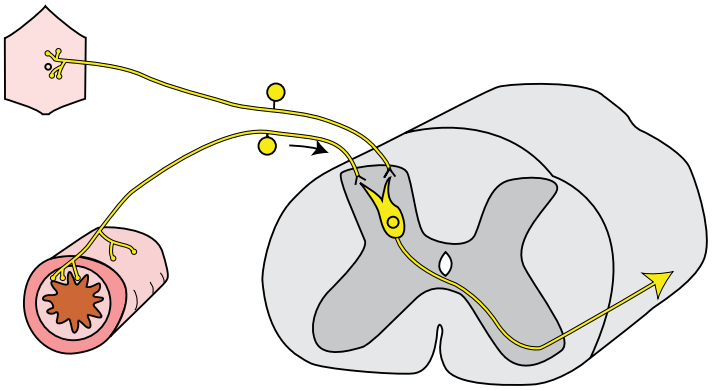
AUTONOMIC SUPPLY OF GASTRO-INTESTINAL TRACT





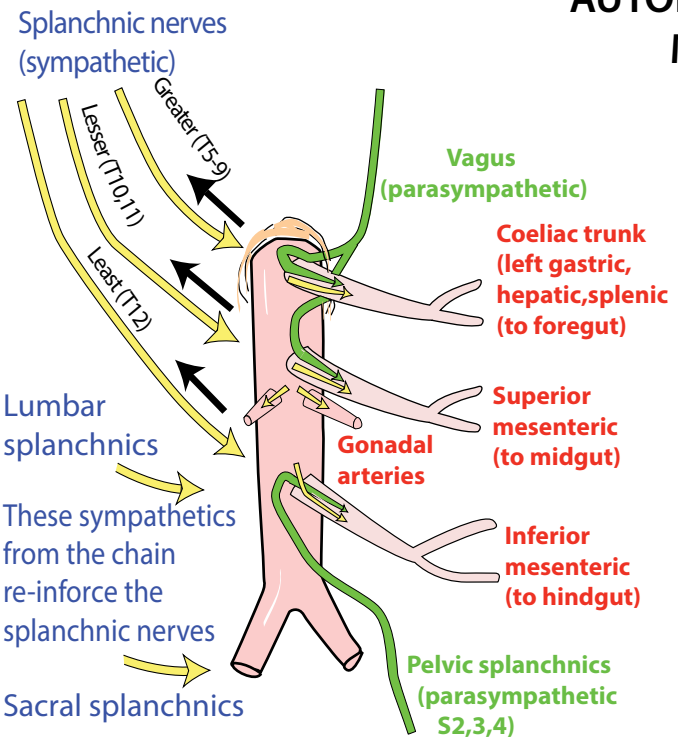
Autonomic nerves are carried to the three divisions - foregut, midgut and hindgut respectively by the coeliac, superior and inferior mesenteric arteries

REFERRED PAIN IN GENERAL VISCERAL AFFERENT NERVES



Pain from an internal organ is referred to a relevant dermatome. **General Visceral Afferents (GVA)** detect pain such as ischaemia from the heart or inflammation or distension of the intestine and these fibres return to the spinal cord mostly with the sympathetic nerves. These GVA relay with the receptor cells in the dorsal horn of the spinal cord which are also receiving sensory input from distant somatic structures, including dermatomes. The central nervous system seemingly cannot accurately distinguish these incoming signals from viscera and incorrectly assigns the visceral pain to a somatic area - a relevant dermatome. In the example shown here the pain from the inflammed appendix is being referred to the peri-umbilical region (T10,11).

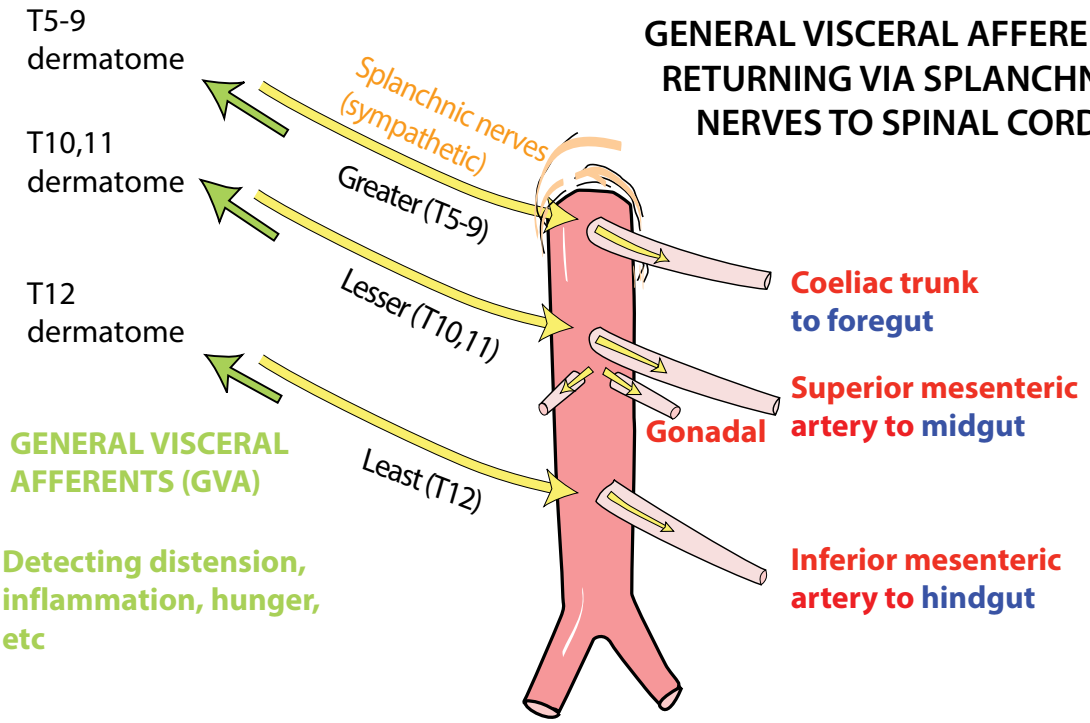
AUTONOMIC SUPPLY TO FOREGUT, MIDGUT AND HINDGUT



Autonomics are an internal adjustment system controlling the activity of the abdominal and pelvic organs. Largely autonomous but influenced by environment and thought processes (e.g. stress leading to diarrhoea or urinary frequency)

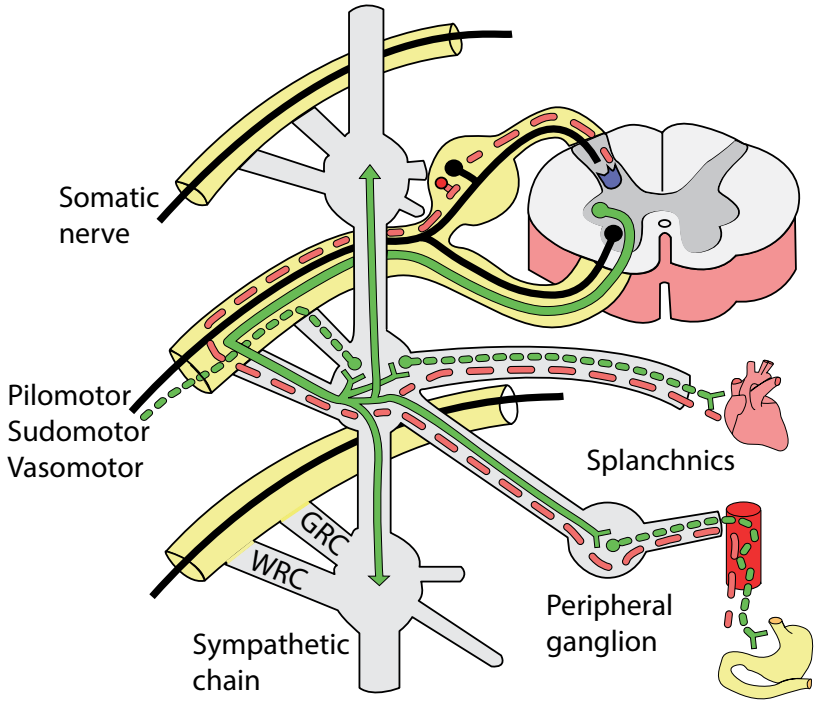
Referred pain is carried by **general visceral afferents** in the sympathetic splanchnic nerves to the dermatomes as indicated by the origins of these nerves. Shown here by black arrows

GENERAL VISCERAL AFFERENTS RETURNING VIA SPLANCHNIC NERVES TO SPINAL CORD



Green arrows indicate the GVAs returning on the splanchnic nerves (yellow) via the sympathetic chain to the spinal cord from foregut, midgut and hindgut

PATHWAY FOR RETURNING GENERAL VISCERAL AFFERENTS (GVA)



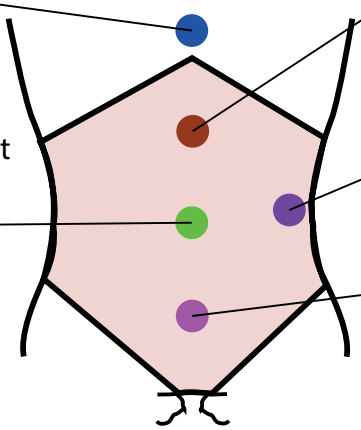
Referred pain

GVAs return to cells in the dorsal grey matter of the spinal cord on the outgoing sympathic fibres. They pass through the peripheral and chain ganglia, then the white ramus communicans before travelling with the sensory branch of the somatic nerve. Their cell bodies are in the dorsal root ganglia.

REFERRED ABDOMINAL AND LOWER CHEST PAIN

LOWER CHEST
Dermatomes T5,6
Oesophagus (hiatus hernia, reflux oesophagitis) or heart

UMBILICAL
Dermatome T10,11
Midgut - half duodenum to transverse colon
ovary/testis



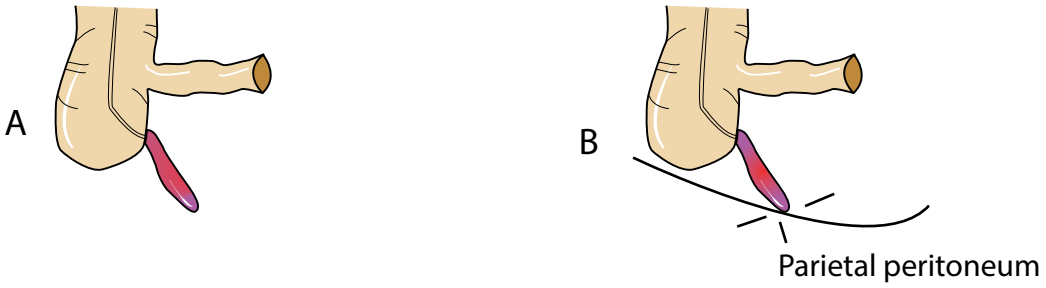
EPIGASTRIC
Dermatomes T7-9
Foregut - stomach and half duodenum

RENAL/URETERIC
Dermatomes T9,10
(lateralised)

SUPRAPUBIC
Dermatomes T12
Hindgut - descending colon, sigmoid and upper rectum

1. All pain is carried in **"general visceral afferents"** by the splanchnic sympathetics, via the sympathetic chain to the spinal cord.
2. It is then referred to the dermatome of that level.
3. All pain for the gastro-intestinal tract and related structures is felt in the midline because of its origin from the midline "gut tube".
4. Pain from the urinary tract can "lateralise" as it was formed bilaterally

REFERRED PAIN IN APPENDICITIS

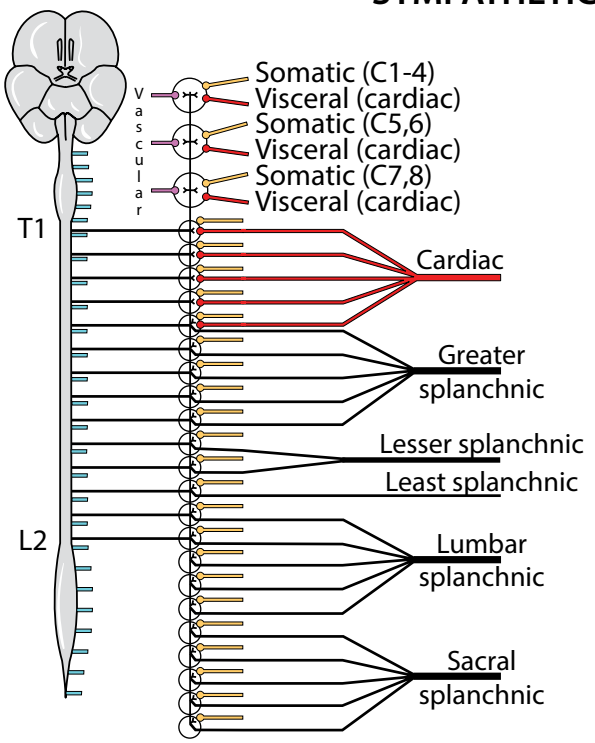


Sequence of events for pain of appendicitis

A. Inflammed appendix triggers general visceral afferents which return to the spinal cord in the lesser splanchnic nerves which supply the midgut. This pain is referred to dermatomes T10,11 - peri-umbilical. So the initial referred pain of appendicitis is felt around the umbilicus in the midline but is of a more generalised nature.

B. When the inflammed appendix touches and irritates the parietal peritoneum in the right iliac fossa, the pain is detected by local somatic nerves which supply this peritoneum. As it is now somatic pain it is more severe and localised. There will be acute tenderness and rebound tenderness to palpation

SYMPATHETIC THORACIC OUTFLOW

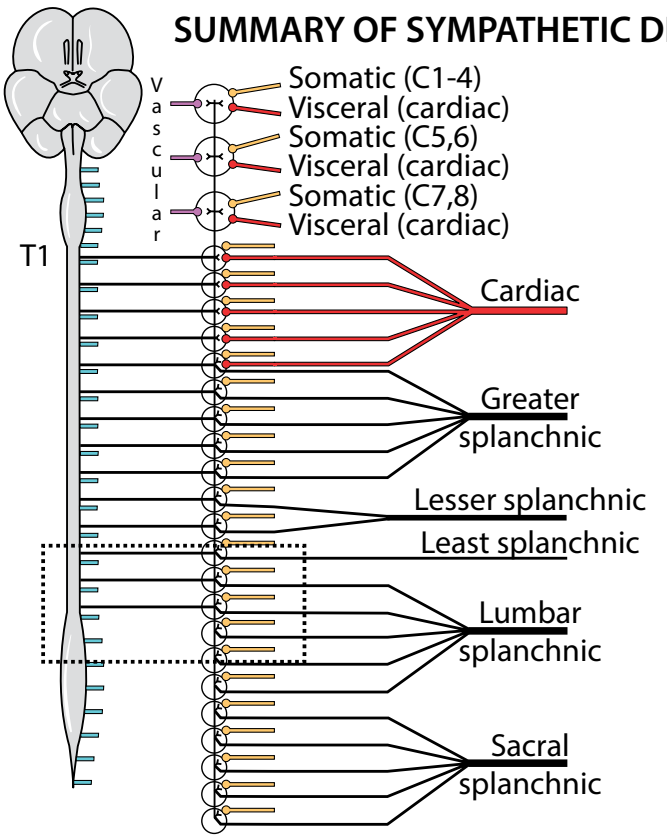


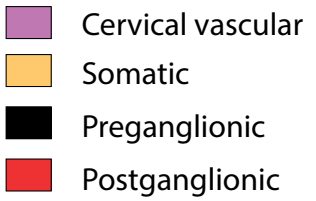
Sympathetics slow down gut activity, dry up secretions, shut sphincters (pylorus, internal anal, vesical), vasoconstrict to redirect blood from abdomen to muscle, heart and brain for fight, flight and fright. They also stimulate the adrenal gland and cause ejaculation.

Sympathetic outflow is from the spinal cord between T1 and L2 via the sympathetic chain and only preganglionic fibres are distributed to the abdomen where they synapse in sympathetic ganglia around the aorta and in the pelvis. Preganglionic fibres reach the adrenal gland directly.

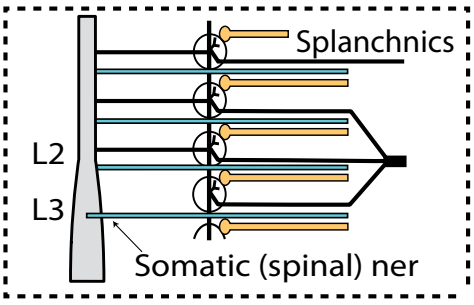
The splanchnic nerves are "reinforced" by sympathetic outflow from the chain in the lumbar and pelvic regions.

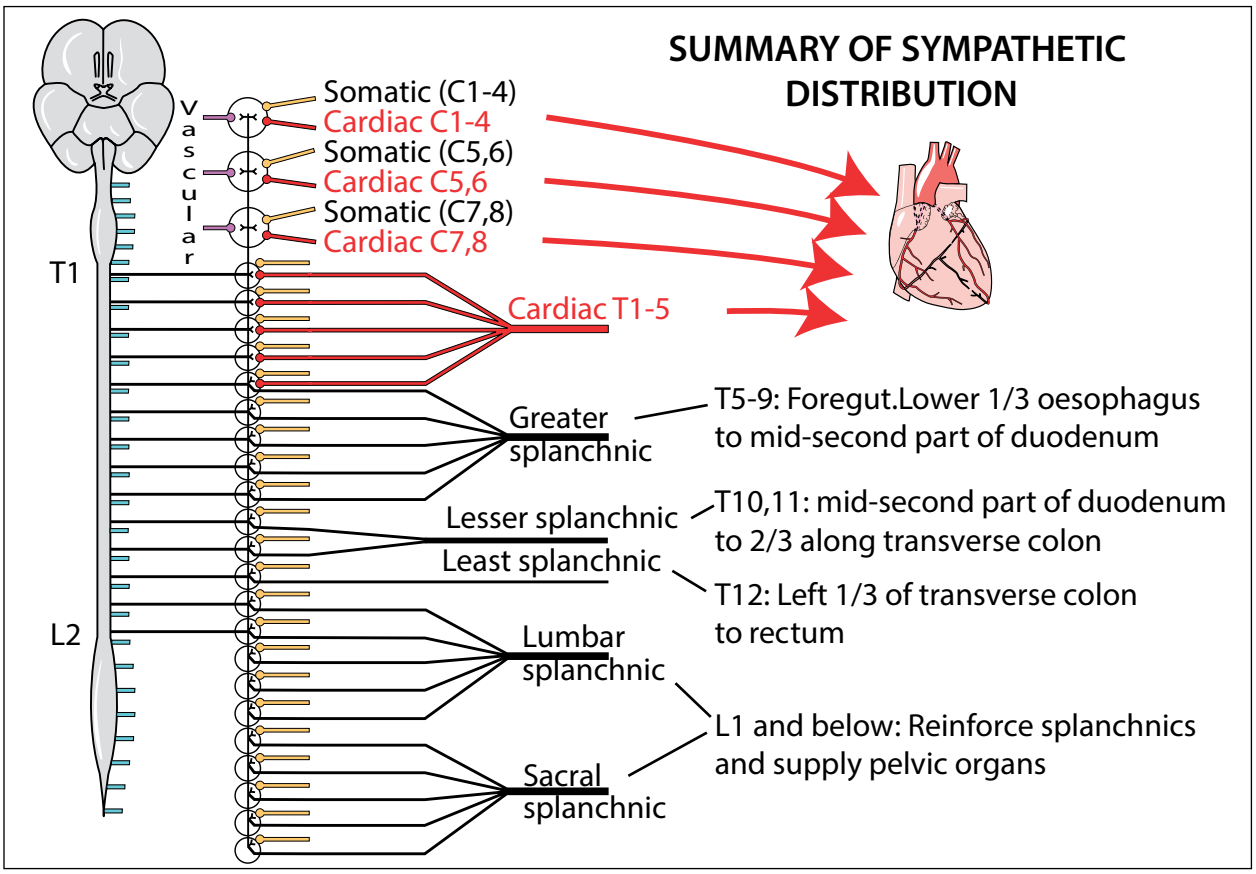
SUMMARY OF SYMPATHETIC DISTRIBUTION BEYOND CHAIN

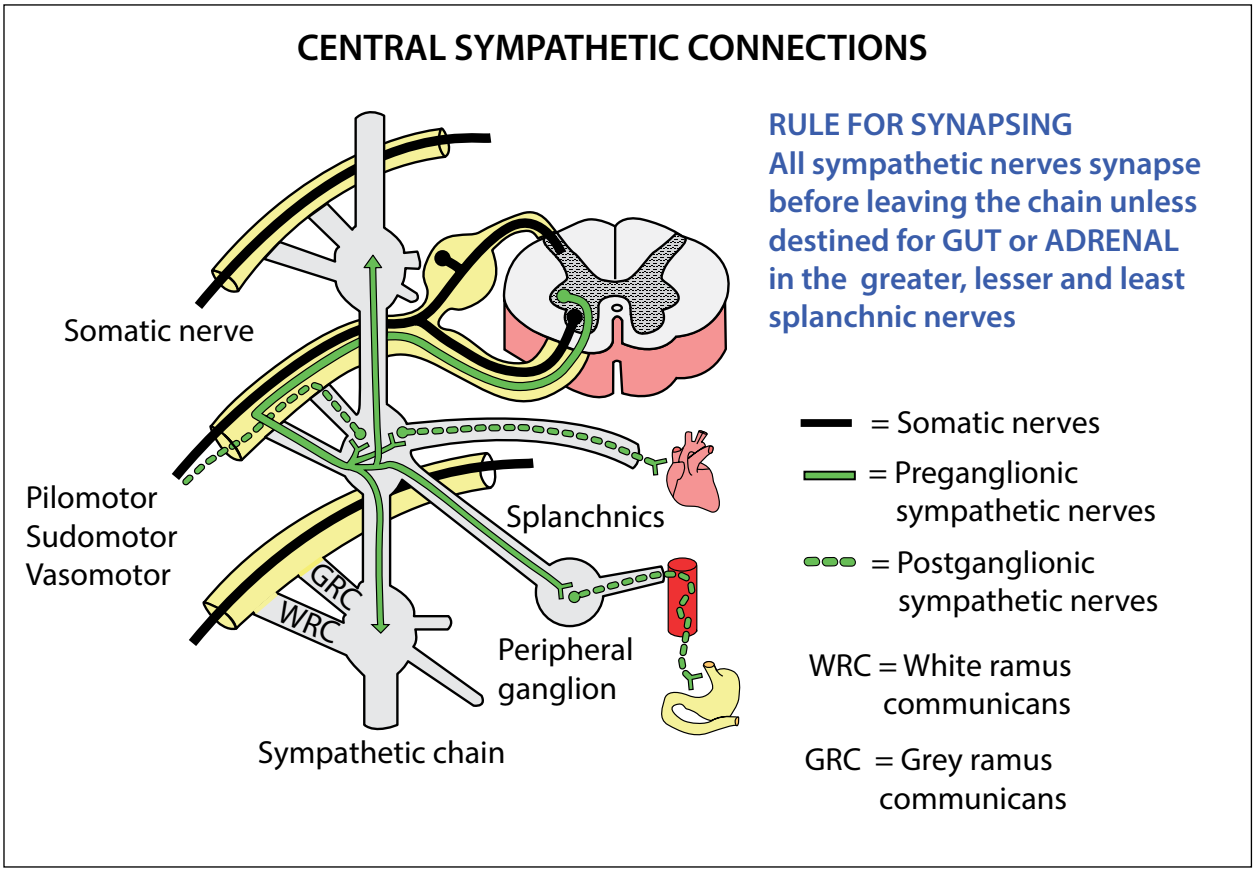




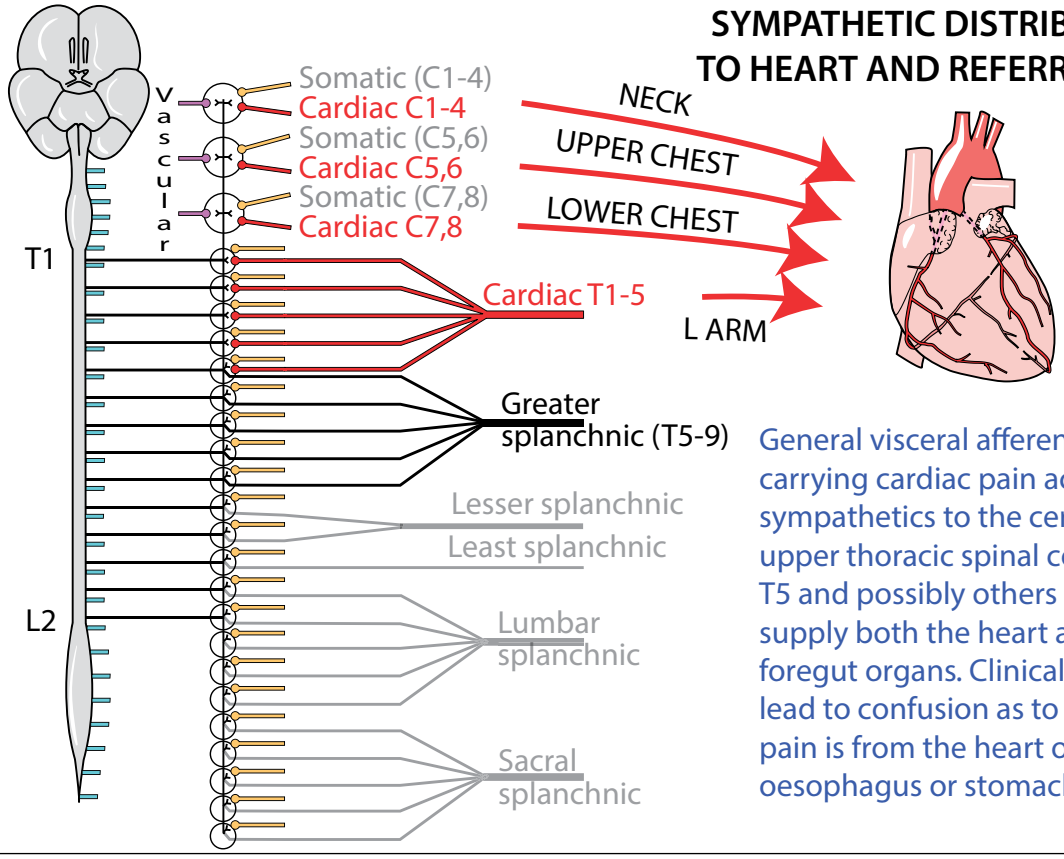
Enlargement of boxed area on left to show extension of the preganglionic fibres in the chain into lower abdomen and pelvis but with no direct connections to spinal cord below L2




SUMMARY OF SYMPATHETIC DISTRIBUTION
Somatic (C1-4)
Cardiac C1-4
Somatic (C5,6)
Cardiac C5,6
Somatic (C7,8)
Cardiac C7,8
Vascular
T1
Cardiac T1-5
Greater splanchnic
T5-9: Foregut.Lower 1/3 oesophagus to mid-second part of duodenum
Lesser splanchnic
T10,11: mid-second part of duodenum to 2/3 along transverse colon
Least splanchnic
T12: Left 1/3 of transverse colon to rectum
L2
Lumbar splanchnic
L1 and below: Reinforce splanchnics and supply pelvic organs
Sacral splanchnic

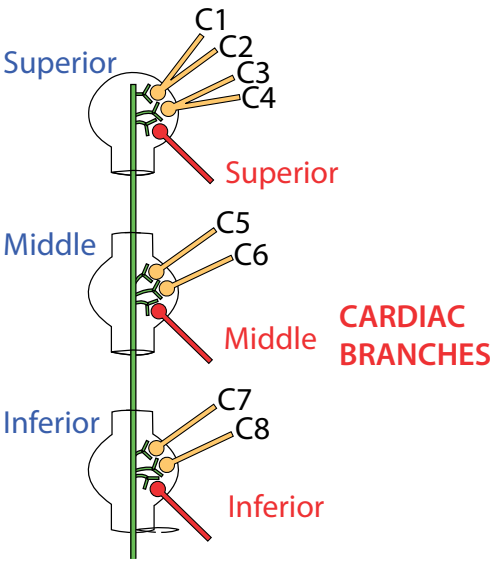

CENTRAL SYMPATHETIC CONNECTIONS
Somatic nerve
Pilomotor
Sudomotor
Vasomotor
Splanchnics
GRC
WRC
Peripheral ganglion
Sympathetic chain
RULE FOR SYNAPSING
All sympathetic nerves synapse before leaving the chain unless destined for GUT or ADRENAL in the greater, lesser and least splanchnic nerves
= Somatic nerves
= Preganglionic sympathetic nerves
= Postganglionic sympathetic nerves
WRC = White ramus communicans
GRC = Grey ramus communicans

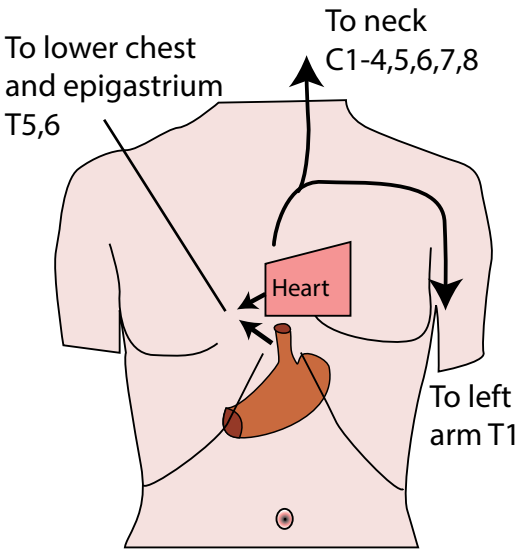
SYMPATHETIC DISTRIBUTION TO HEART AND REFERRED PAIN



General visceral afferents (GVA) carrying cardiac pain accompany sympathetics to the cervical and upper thoracic spinal cord levels. T5 and possibly others levels supply both the heart and foregut organs. Clinically, this can lead to confusion as to whether pain is from the heart or lower oesophagus or stomach.

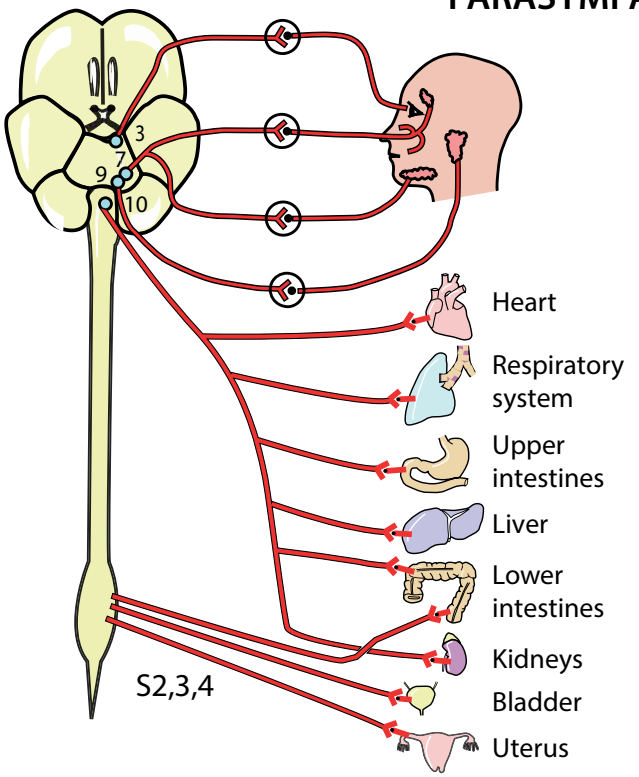
CARDIAC REFERRED PAIN





General visceral afferents from the heart return to the spinal cord on branches of the sympathetic chain. As there are cardiac branches from each of the cervical sympathetic ganglia and also from T1-5 in the upper thoracic chain, there can be referred pain to the dermatomes associated with these ganglia. C1-C8 dermatomes include the neck and upper limb

PARASYMPATHETIC CRANIOSACRAL OUTFLOW

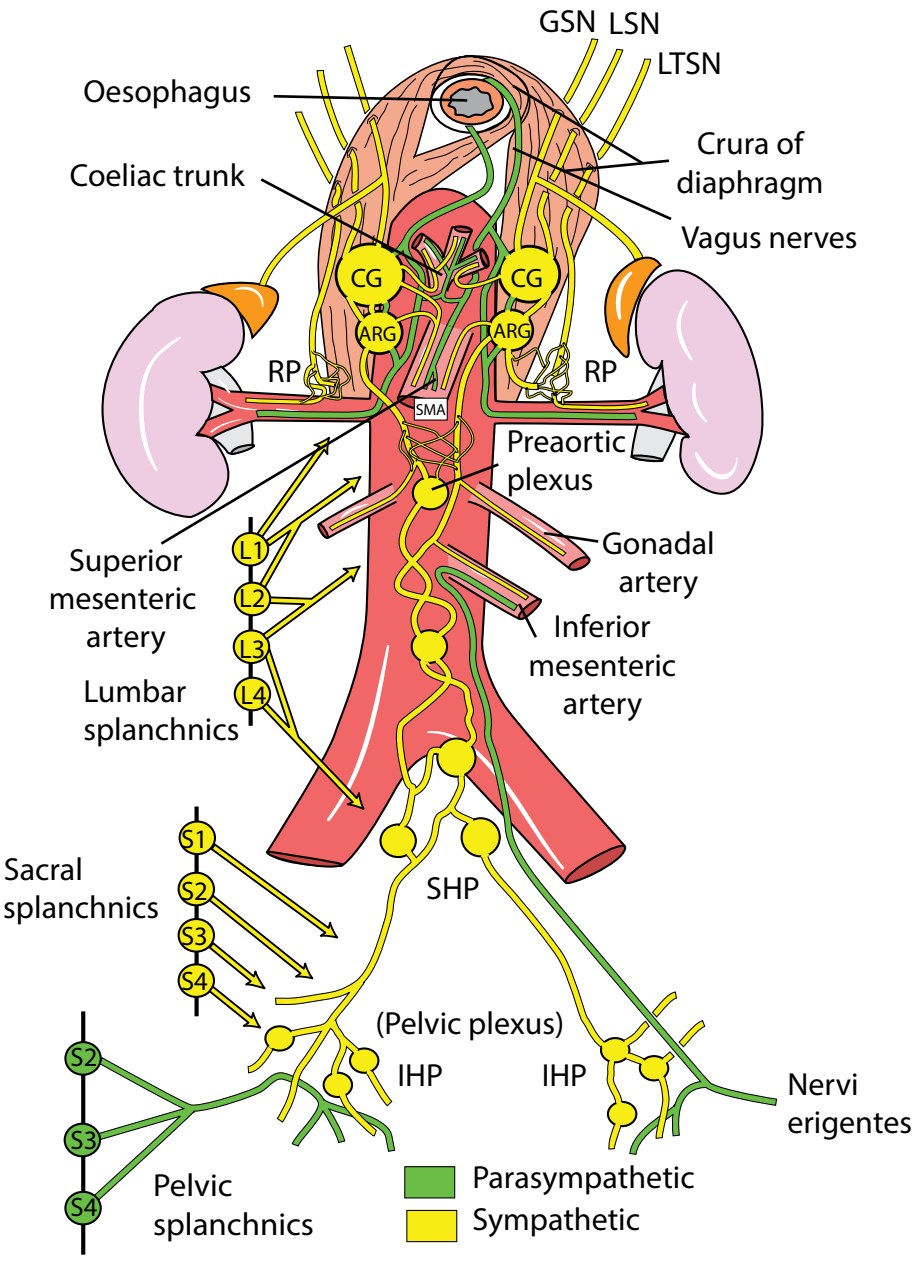


Parasympathetics are active during rest and quiet activity, causing peristalsis, secretions, opening of sphincters, contraction of bladder and uterus and stimulation of erection of penis and clitoris.

Parasympathetic outflow is from the vagus and S2, 3, 4 section of the spinal cord only. Preganglionic fibres synapse in small parasympathetic ganglia in the walls of the organs. The vagus supplies the bowel as far as two thirds across the transverse colon and the pelvic outflow supplies all below that level.

The head is supplied by 4 specific ganglia.

ABDOMINOPELVIC AUTONOMICS



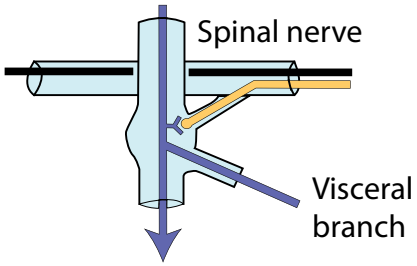
GSN: Greater splanchnic nerve
LRSN: Lesser splanchnic nerve
LTSN: Least splanchnic nerve
CG: Coeliac ganglion
ARG: Aorticorenal ganglion

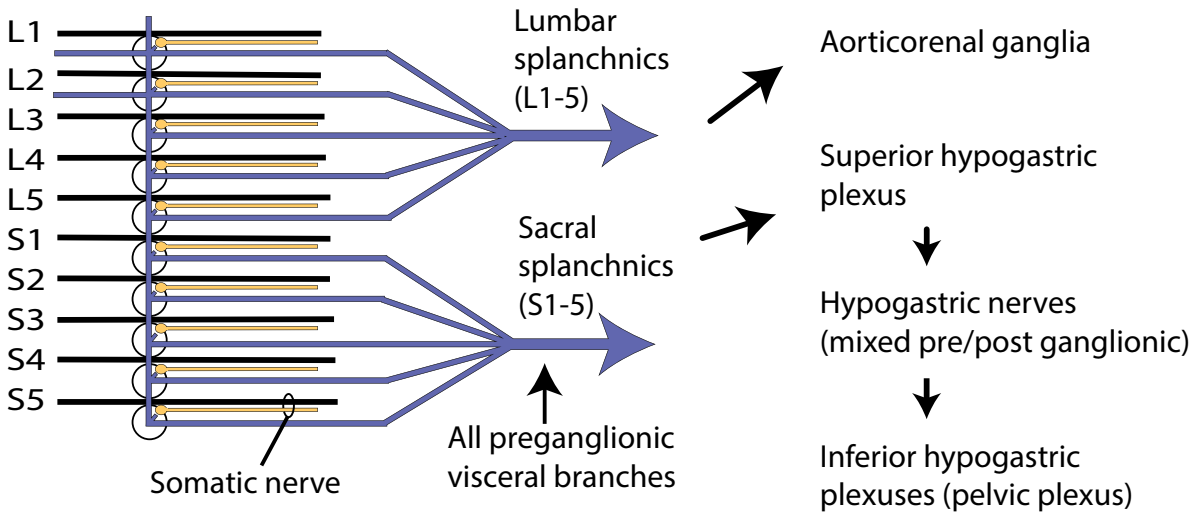
RP: Renal plexus
SHP: Superior hypogastric plexus
IHP: Inferior hypogastric plexus
(The two IHPs together make the pelvic plexus)

Other plexuses not shown: SRP: Suprarenal plexus. AAP: Abdominal aortic plexus. IMP: Inferior mesenteric plexus

LUMBOSACRAL SYMPATHETICS

Lumbar and sacral splanchnic nerves leave the sympathetic chain ganglia as preganglionic fibres. They do not synapse if they are destined to go to the gut. They synapse later in the hypogastric and pelvic plexuses





SECTION 5

Head and Neck

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A Visual Guide to Clinical Anatomy, First Edition. Robert H. Whitaker.

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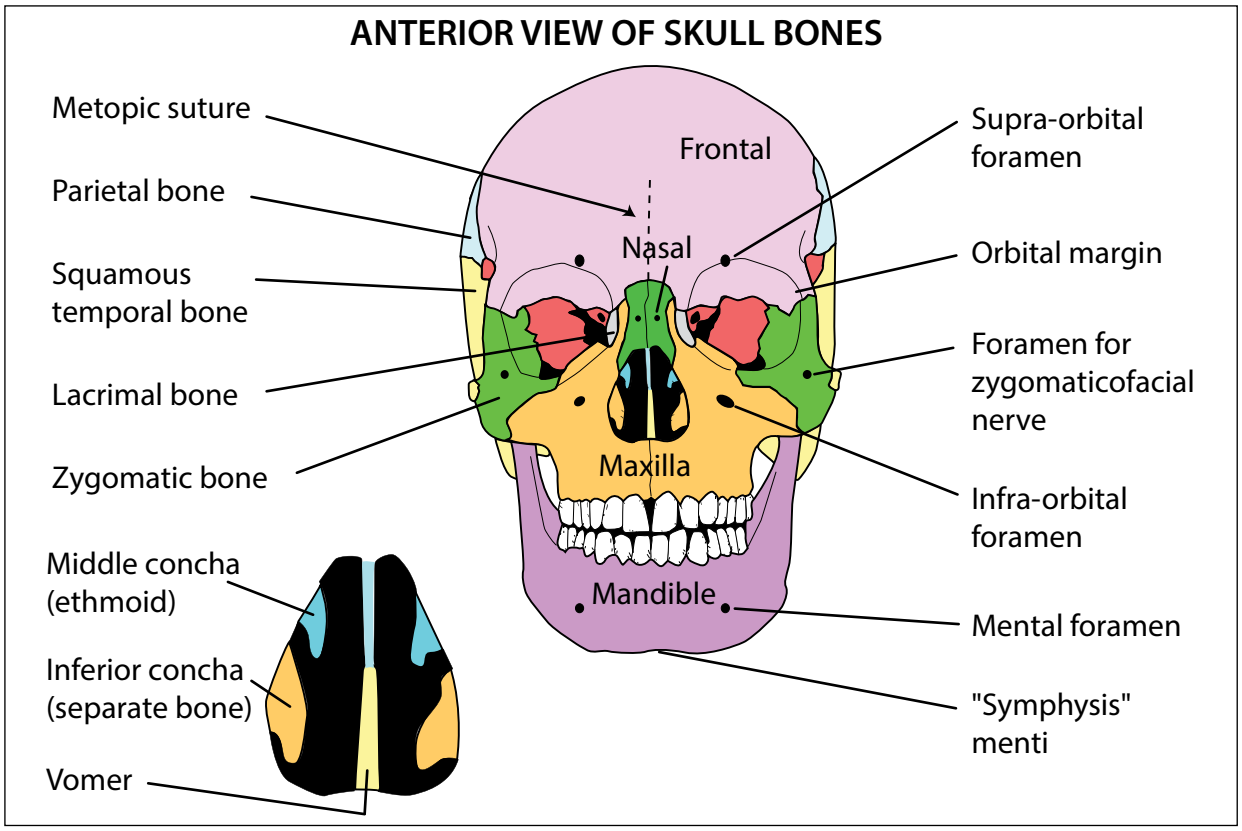
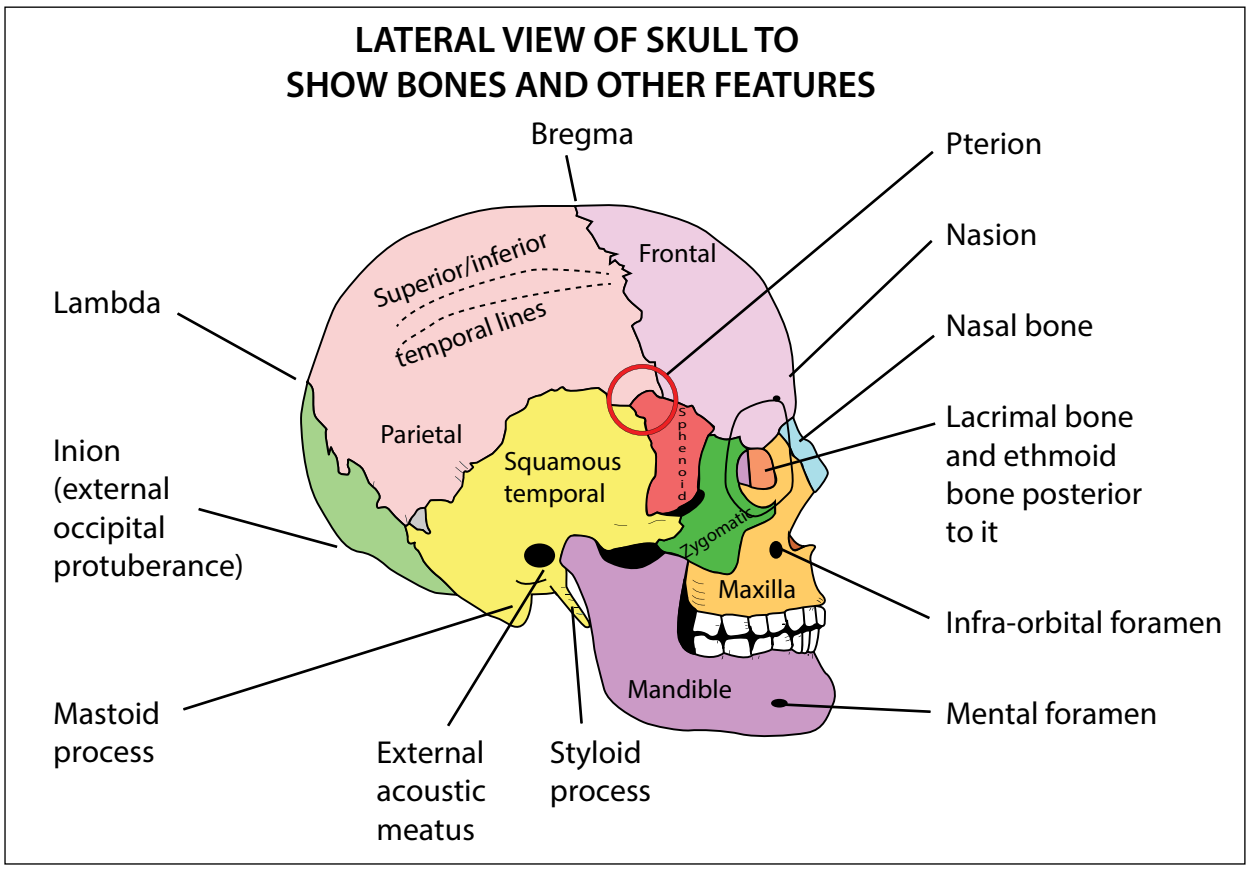
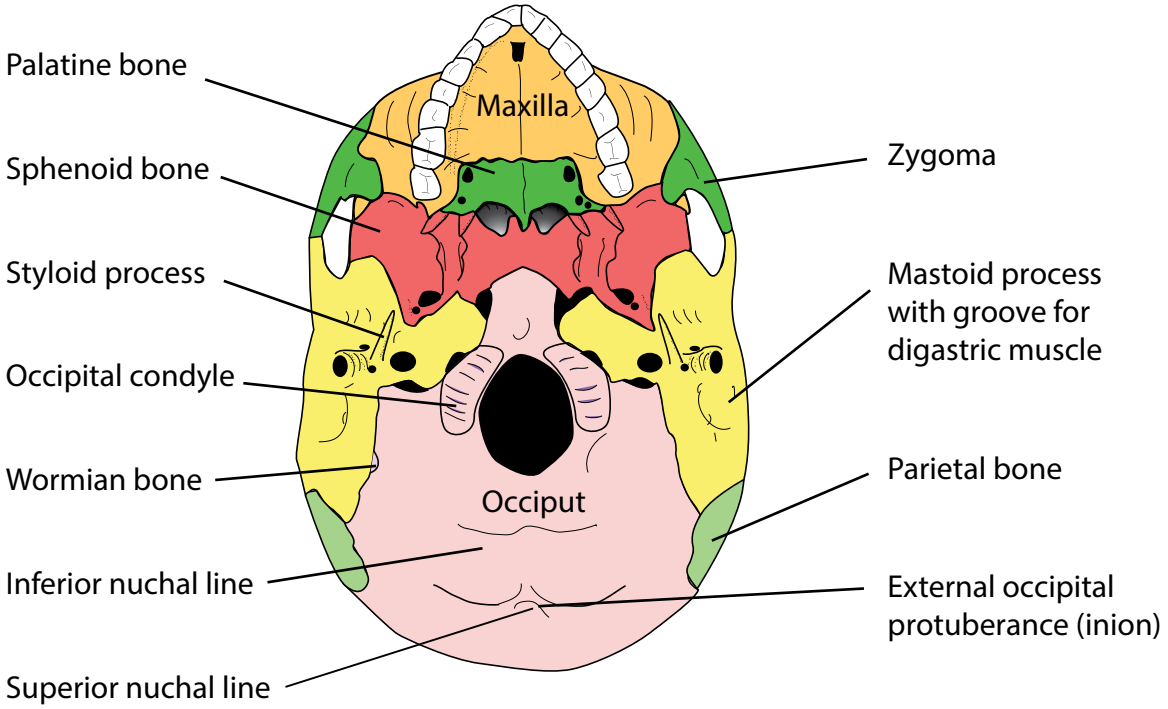
5.1 Skull Bones, Air Sinuses and Scalp

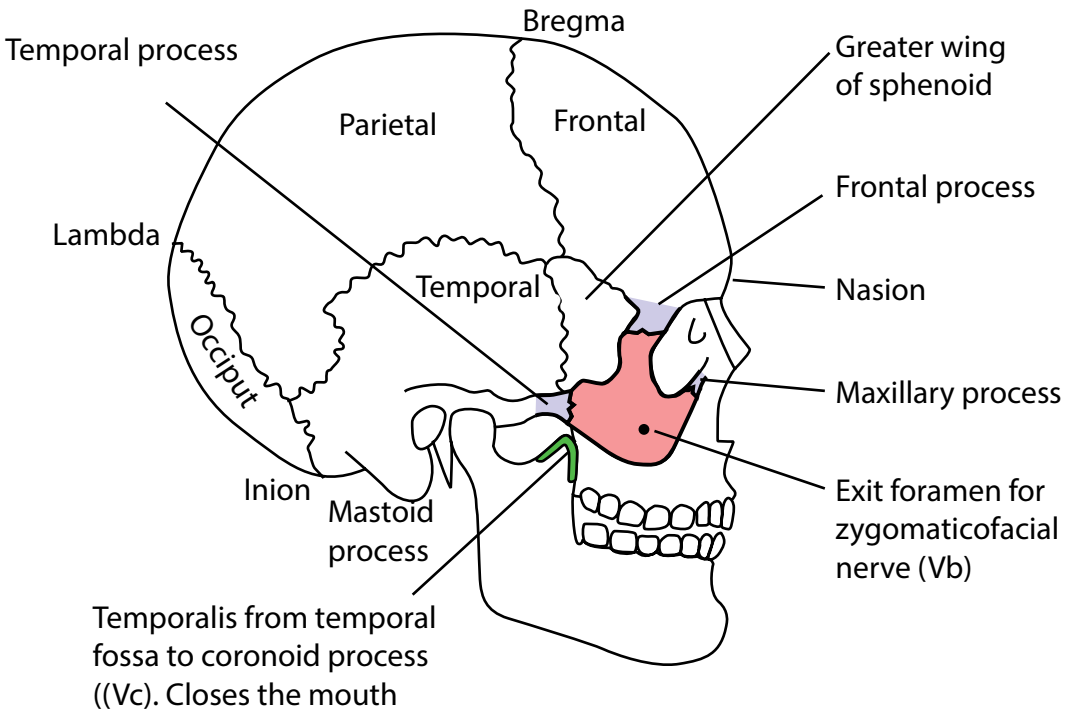




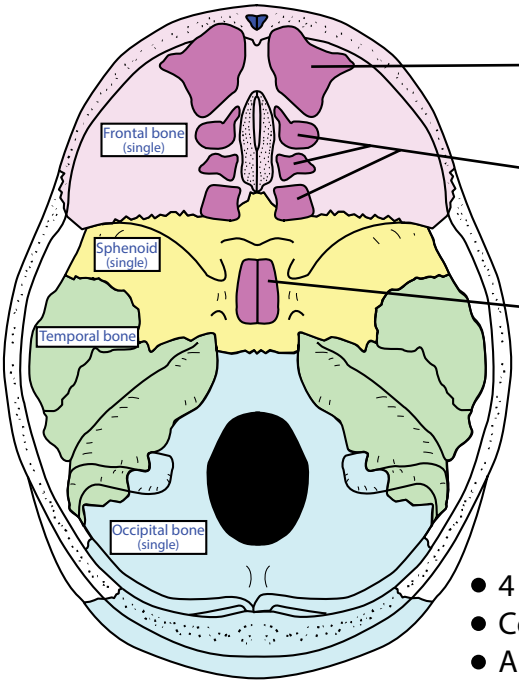
INFERIOR VIEW OF SKULL TO SHOW BONES AND OTHER FEATURES



SKULL - LATERAL VIEW TO SHOW ZYGOMATIC BONE



PARANASAL SINUSES



FRONTAL
Absent at birth, appear at 2 yr

ETHMOIDAL
(Anterior, middle and posterior)

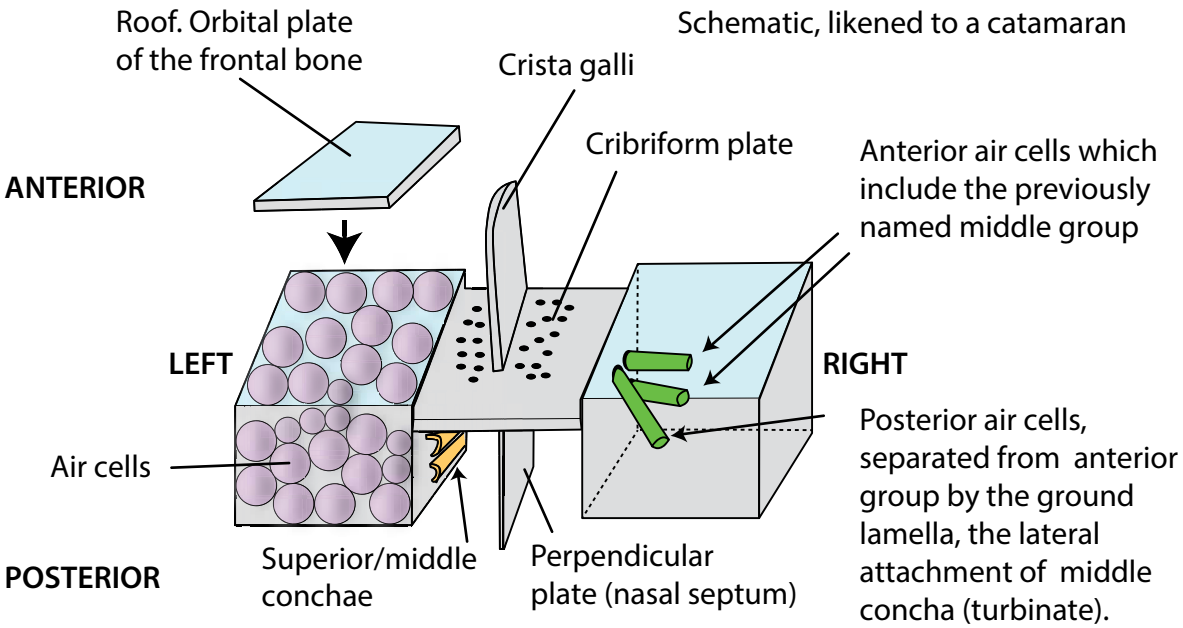
SPHENOIDAL

MAXILLARY, ETHMOIDAL and SPHENOIDAL
Appear at birth and enlarge.

- 4 pairs, lined by respiratory epithelium
- Communicate with nose via ostia
- Abundant sensory nerve supply at ostia
- Mucus is drained by cilia
- Lighten skull, warm and moisten air, resonate voice

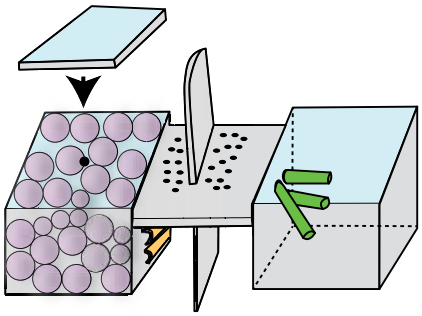
ETHMOID BONE AND SINUSES

Schematic, likened to a catamaran



Ethmoid bone: 2 sinuses joined by the cribriform plate. **Roof:** Orbital plate of the frontal bone. **Anterior:** Lacrimal bone. **Posterior:** Sphenoid bone

ETHMOIDAL SINUSES 2

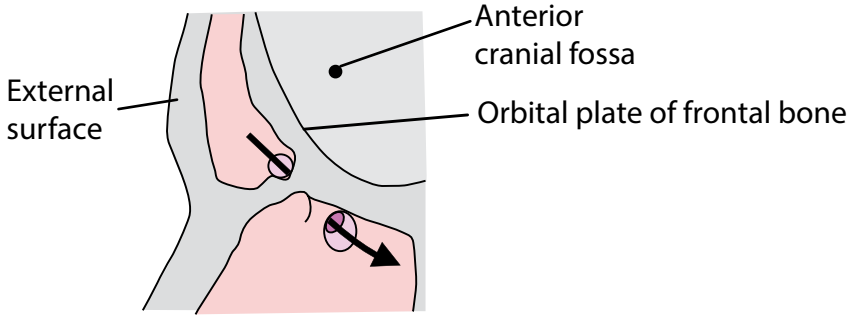


Ethmoidal sinuses: Lie between the orbit and nose in the lateral (labyrinthine) part of the bone. See image of lateral wall of nasal cavity for drainage sites.
Septa: Lie between 3-18 lots of air cells
Blood supply: Supra-orbital, anterior/posterior ethmoidal, sphenopalatine arteries
Lymph drainage: Submandibular and retropharyngeal nodes
Nerve: Supra-orbital (Va), Anterior ethmoidal (Va), lateral posterior superior nasal (Vb), posterior ethmoidal (Va) nerves

The ethmoid bone has many similarities to a catamaran:
2 bodies = hulls. Cribriform plate = deck. Crista galli = mast/sail.
Perpendicular plate = centreboard

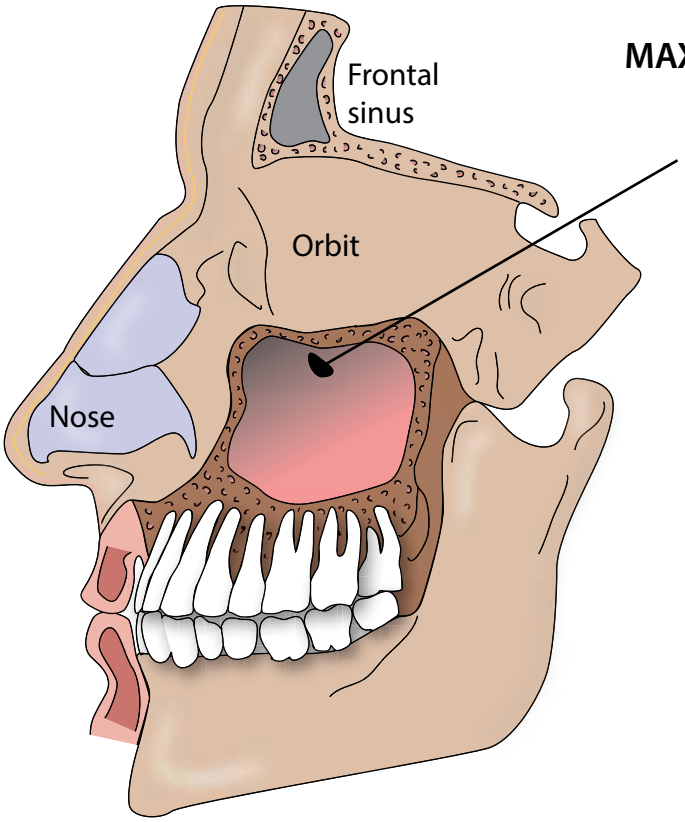
FRONTAL SINUSES

Appear: 2 years; Unequal in size; Bony septum between them
Lie: Between orbit and anterior cranial fossa
Nerves: Supra-orbital and supratrochlear nerves
Blood supply: Supra-orbital and supratrochlear arteries
Lymph drainage: Submandibular nodes
Veins: Diploic and superior ophthalmic



Drainage: To ostium (lower medial aspect), then to middle meatus via frontonasal canal (anterior end of hiatus semilunaris). May drain via infundibulum from anterior ethmoidal sinus

MAXILLARY SINUS 1

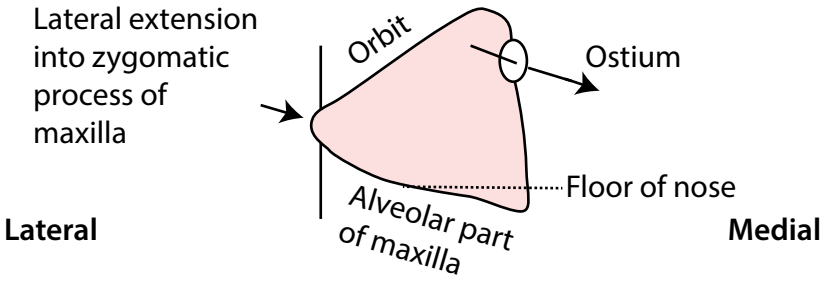


Note that the opening is high up on the medial wall

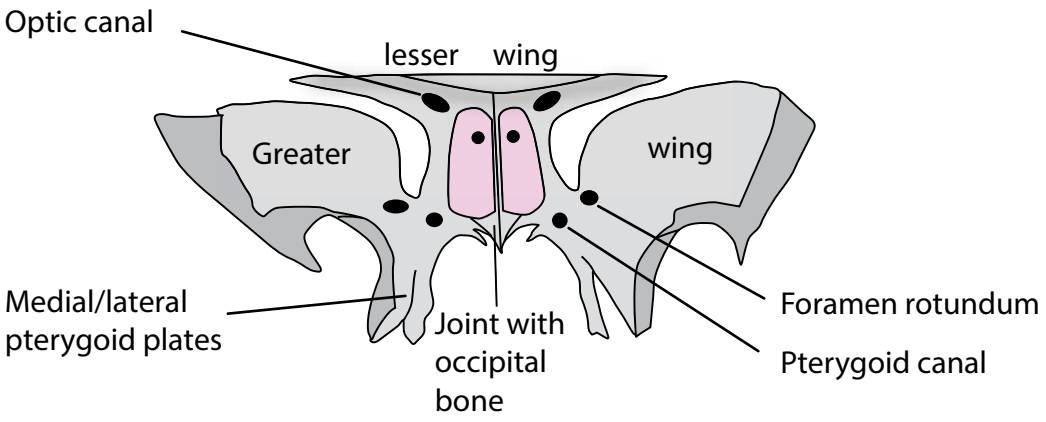
- Largest sinus
- Drains to middle meatus
- Small at birth, enlarges 6-7 years
- Respiratory epithelium
- Lighten skull
- Warm and moisten air
- Resonate voice

MAXILLARY SINUS 2

Shape: Pyramidal
Walls: Anterior and posterior walls are maxilla
Drainage: Into posterior hiatus semilunaris of middle meatus.
Ostium is 3-4mm, high on posterior end of nasal wall; may be a second ostium
Blood supply: Small arteries from facial, maxillary, infra-orbital and greater palatine
Lymph drainage: Submandibular glands
Nerve supply: Anterior/middle/posterior superior alveolar with secretomotor from pterygopalatine ganglion
Feature: The infra-orbital nerve lies in its ridge (junction of roof and anterior wall)
Note: The sinus is partially occupied by developing adult teeth in children. Removal of molar teeth in adults may lead to a fistula between the sinus and mouth

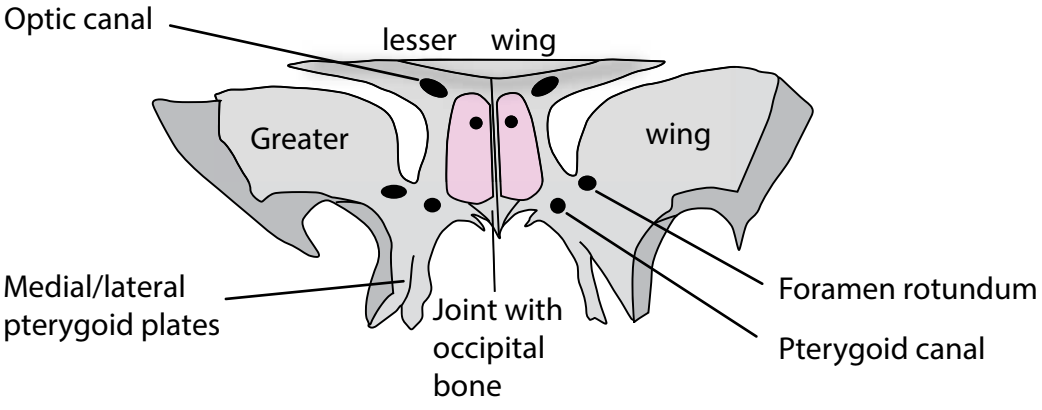


SPHENOID BONE 1
POSTERIOR VIEW TO SHOW SINUSES



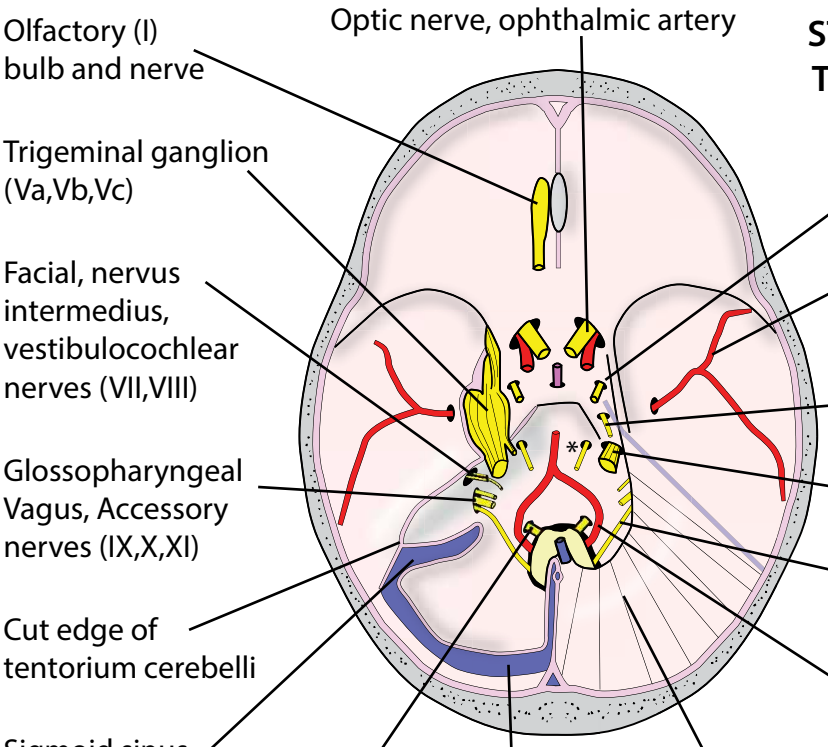
SPHENOIDAL SINUSES
Paired in body of sphenoid; **Septum:** Asymmetrical
If small: Then anterior to pituitary fossa; **If large:** Then beneath pituitary fossa, extending posteriorly to basi-occiput and laterally into greater wing; **Ostium:** In anterior wall, opening into spheno-ethmoidal recess

SPHENOID BONE 2
POSTERIOR VIEW TO SHOW SINUSES

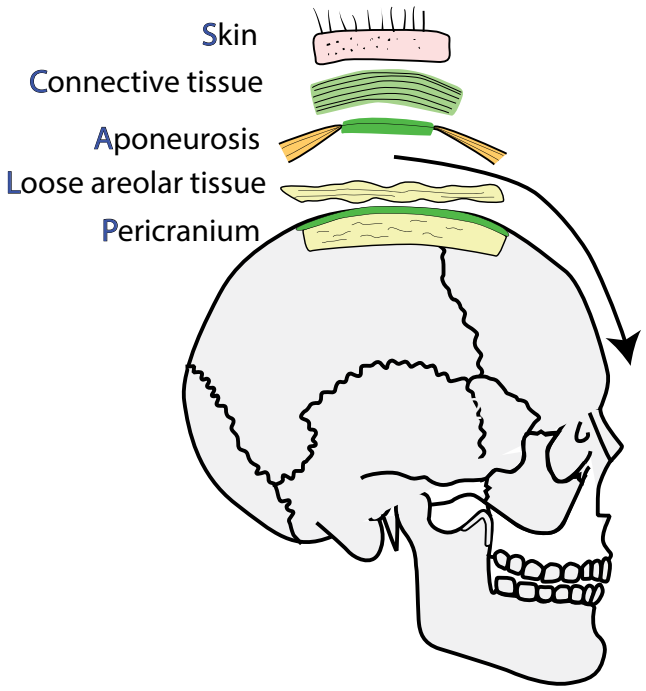


Lateral: Cavernous sinuses, internal carotid artery and maxillary nerve; **Posterior:** Posterior cranial fossa and pons; **Inferior:** Roof of nasopharynx, nerve of pterygoid canal and palatovaginal canal (containing pharyngeal branch of maxillary nerve); **Walls:** Indented by pterygoid and palatovaginal canals, internal carotid artery and maxillary nerve (Vb); **Nerve supply:** Posterior ethmoidal from maxillary and branches of pterygopalatine ganglion; **Blood supply:** Posterior ethmoidal and sphenopalatine branches of maxillary artery; **Lymph drainage:** Retropharyngeal

STRUCTURES PIERCING THE DURA IN THE BASE OF THE SKULL



LAYERS OF THE SCALP



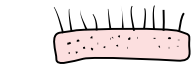
In a head or scalp injury, blood will run forwards between these two layers and this will lead to "black eyes"

There are 2 reasons why scalp wounds bleed so freely.

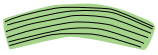
1: The blood vessels are held open by the connective tissue.

2: The arteries are supplied by branches of both the internal and external carotid arteries and thus bleed from both ends of a cut vessel.

LAYERS OF SCALP

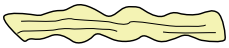


Skin → Thick, many sebaceous glands, muscles inserted into it

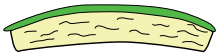


Connective tissue → Very vascular

Aponeurosis
- Central: → Epicranial aponeurosis
- Anterior/posterior → Occipitalis onto superior nuchal line (posterior auricular branch of facial (VII)
- Anterior/posterior → Frontalis into skin of eyebrow and orbicularis oculi, (temporal/zygomatic branches of facial (VII)

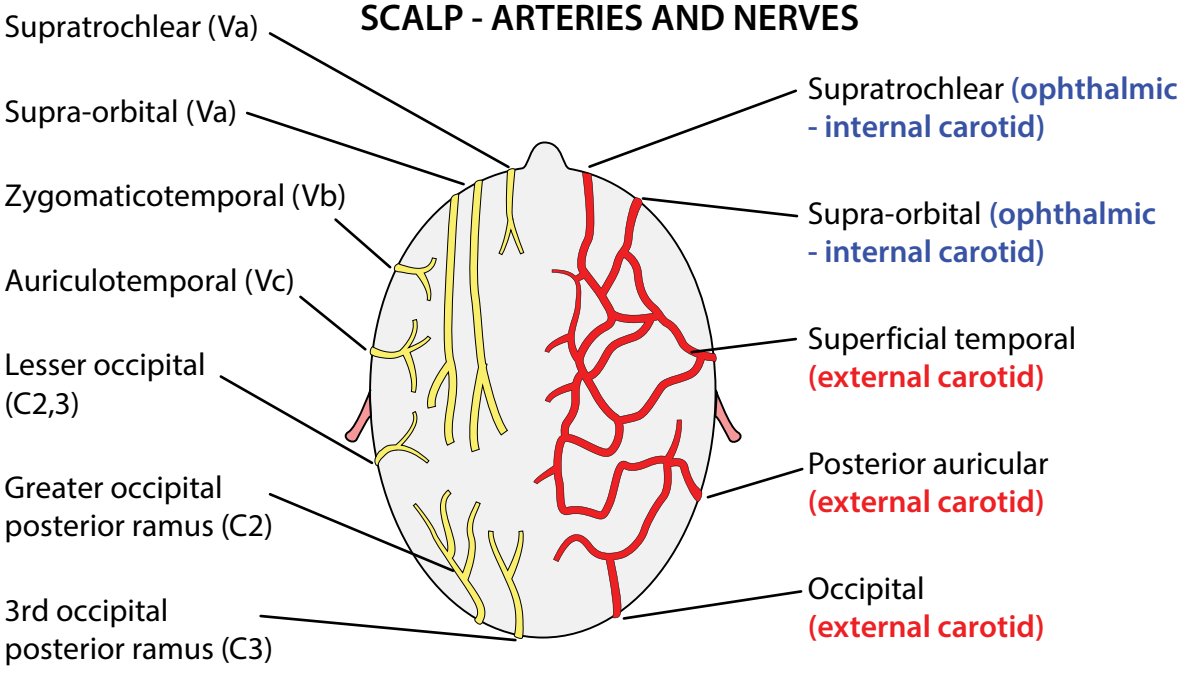


Loose areolar tissue



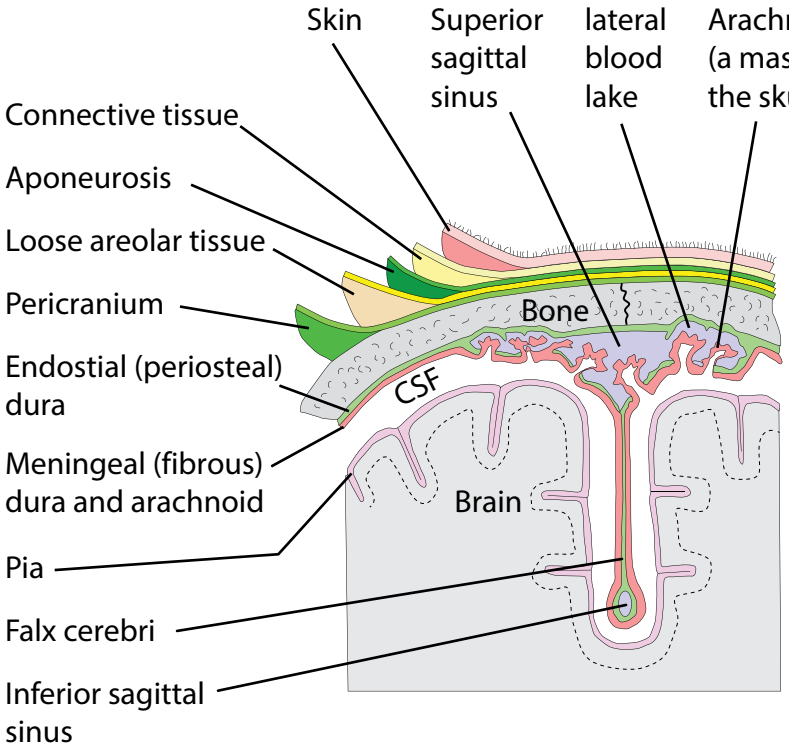
Pericranium → Periosteum, loosely attached to bone, haematoma possible under it but limited to each bone

SCALP - ARTERIES AND NERVES



Note: Arterial anastomosis between branches of internal and external carotids leading to bleeding from both ends of a severed artery in the scalp. Scalp arteries are also held open by fibrous tissue.

CORONAL SECTION OF SKULL, SCALP AND MENINGES IN MIDLINE



CEREBROSPINAL FLUID

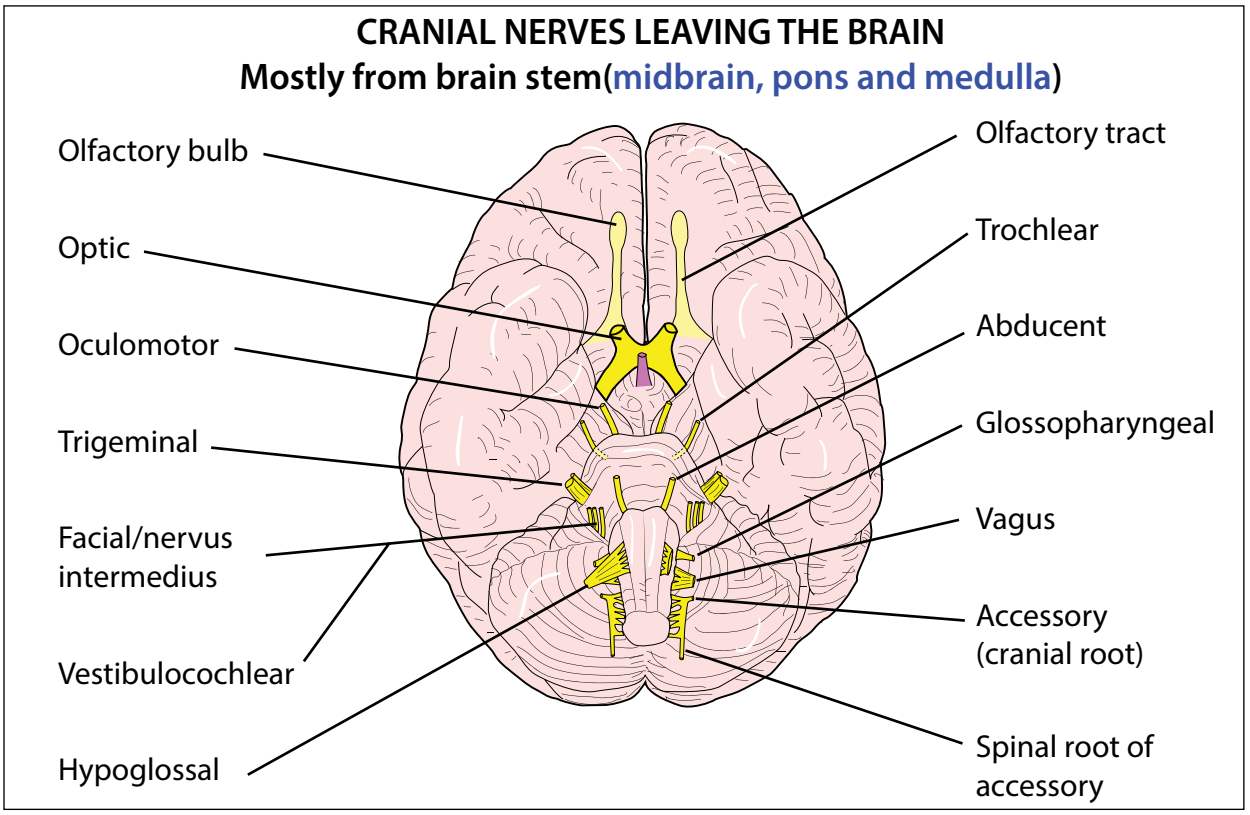
130ml: - 30ml in ventricles, 75ml in spinal system, 25ml in cranium.

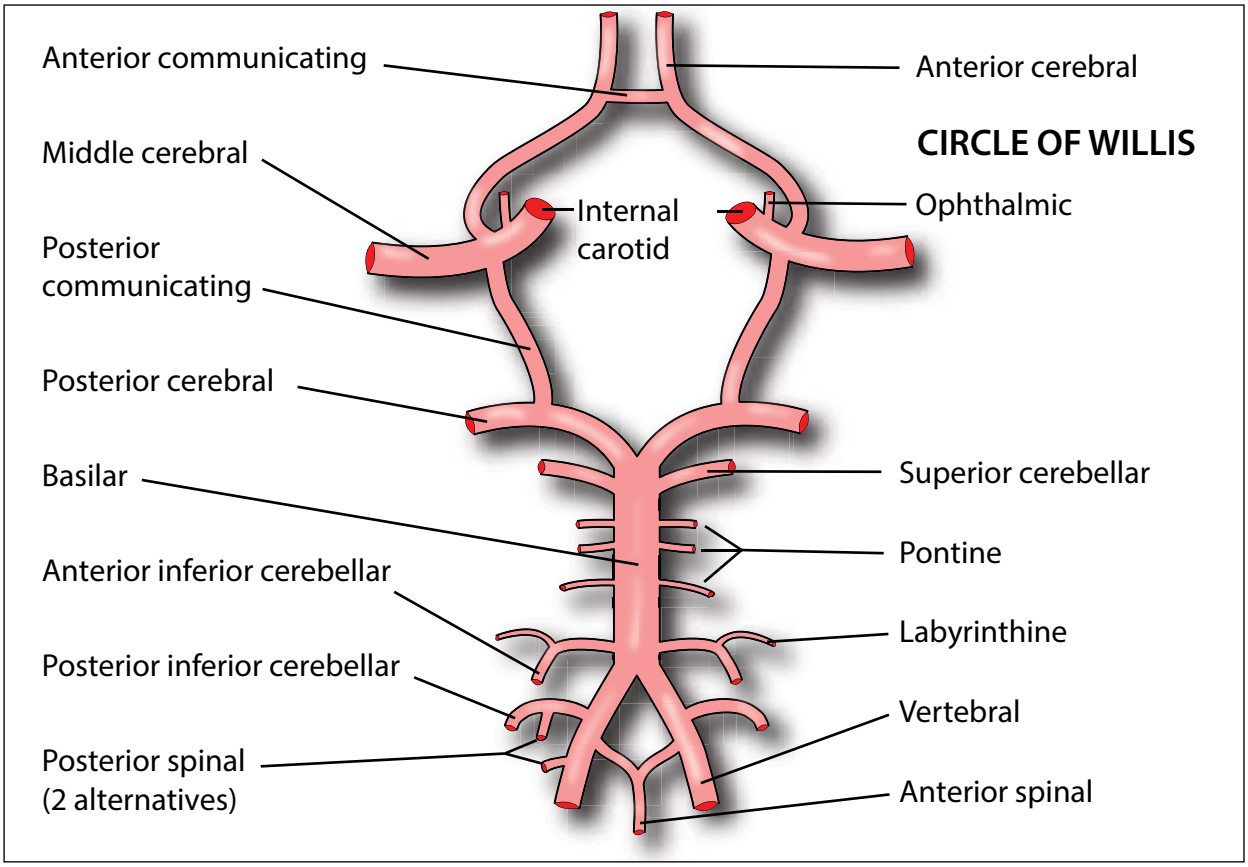
Turn over: 500ml per day from choroid plexus to 4th ventricle to subarachnoid space to arachnoid villi

Pressure: 130mm of water.

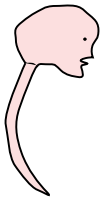
Function: Brain floats in it, some metabolic exchange, effectively reduces weight of brain from 1500g to 50g

5.2 Brain, Spine, Spinal Cord and Vessels





VERTEBRAL COLUMN - FEATURES AND CURVATURES



Primary curvature

Secondary curvatures (cervical and lumbar)

VERTEBRAE

- 7 cervical (atlas, axis and C7 are atypical)
- 12 thoracic
- 5 lumbar
- 5 sacral (fused)
- 4 coccygeal (3-5)

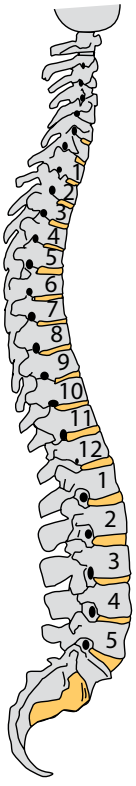
FUNCTIONS

- Weight bearing
- Movement of trunk
- Support for limbs
- Protection of spinal cord
- Production of blood
- Metabolic reserves (Calcium, etc)

WEIGHT BEARING

- Aided by: secondary lordosis
  - 40% bony wedge
  - 60% disc wedge
- Caused/held by: extensor spinal muscles
- Aided by: intervertebral discs (dampeners, resilience, compressible)

VERTEBRAL COLUMN - MOVEMENTS



CERVICAL (7)

Flexion
Extension
Lateral flexion

ATLANTO-OCCIPITAL

Flexion/extension

ATLANTO-AXIAL

Rotation only

THORACIC (12)

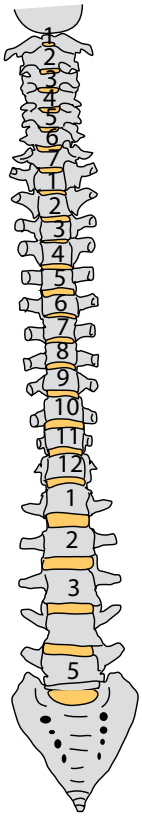
Rotation only

LUMBAR (5)

Flexion/extension
Lateral flexion

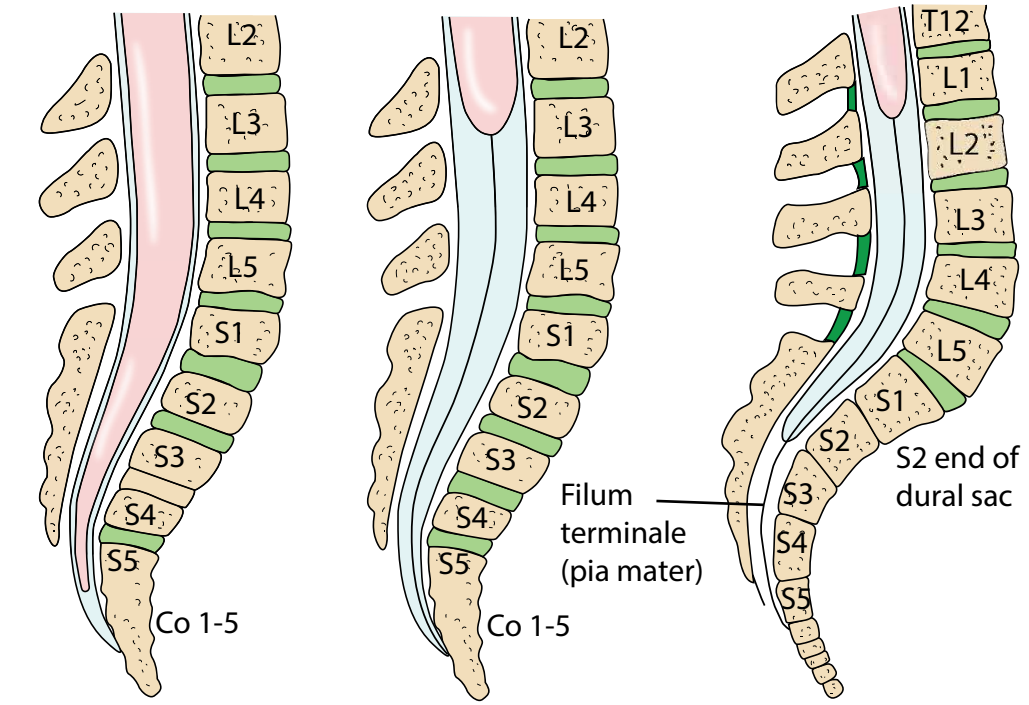
SACRAL (5 FUSED)

No movement



Movements at facet and intervertebral joints are individually small but accumulatively considerable

RELATIONSHIP OF SPINAL CORD TO VERTEBRAL COLUMN

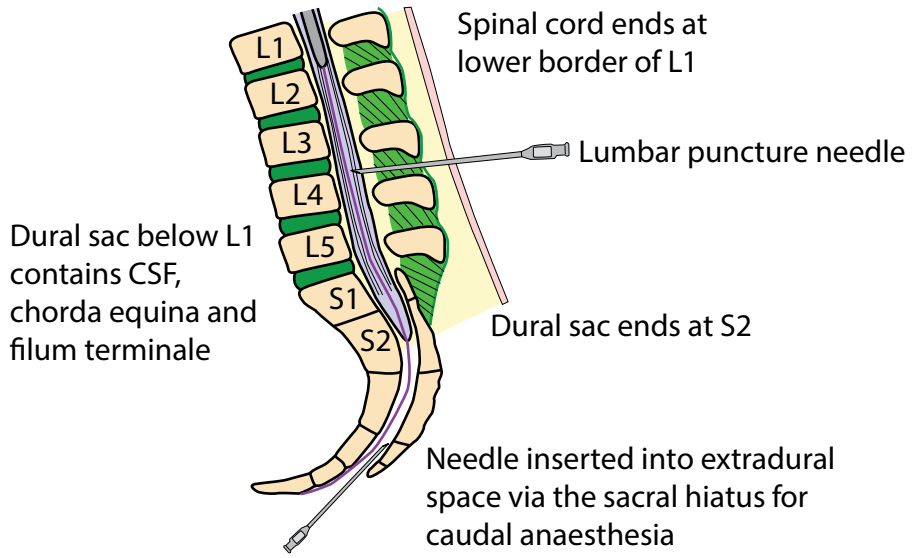


Cord ends at coccyx in 3 month **FETUS**

Cord ends at L3 in **NEWBORN**

Cord end at lower L1 in **ADULT**

LUMBAR PUNCTURE AT L4/5 OR L3/4



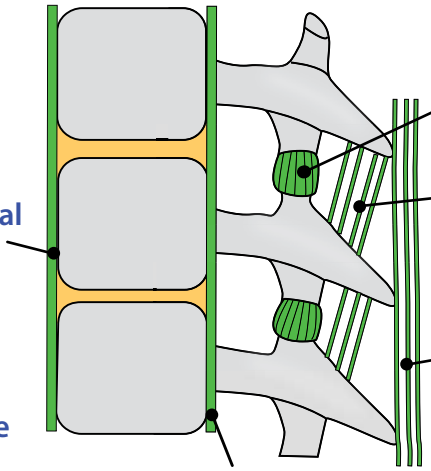
A lumbar puncture needle passes through skin, underlying fatty tissue supraspinous and interspinous ligaments, dura mater and arachnoid

VERTEBRAL COLUMN - LIGAMENTS

Anterior atlanto-occipital membrane

Anterior longitudinal ligament

Above becomes **tectorial membrane** (C2 to occiput)



Posterior longitudinal ligament. Attached firmly to disc, lightly to body to allow venous egress

LIGAMENTS

Interarticular
Between facet joints

Interspinous
Weak, fused with supraspinous

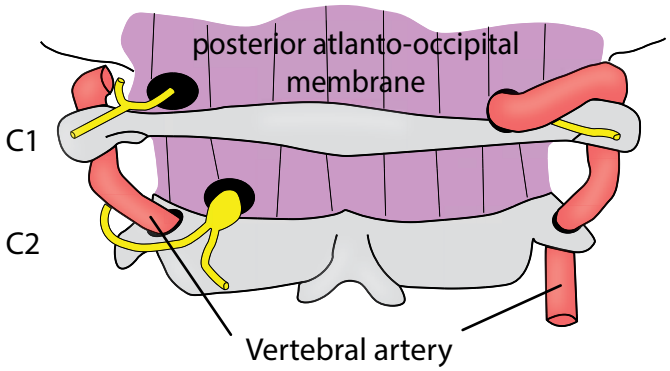
Supraspinous
White, strong, fibrous, into ligament nuchae above

Ligamentum flavum (Not shown) between laminae like tiles on a roof - under surface of one above to outer surface of one below

ATLANTO-OCCIPITAL MEMBRANES

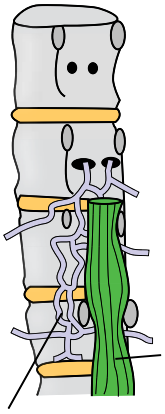
Posterior view

The posterior atlanto-occipital membrane is a separate membrane between the posterior arch of the atlas and the posterior rim of the foramen magnum. It could be regarded as an extension of the ligamentum flavum.



The posterior longitudinal ligament , lying on the posterior aspects of all vertebrae, becomes the tectorial membrane between the atlas and the foramen magnum (not shown).

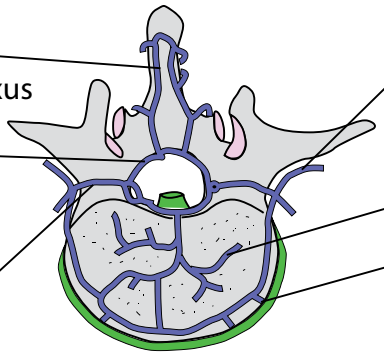
SPINAL COLUMN - VEINS AND SOME LIGAMENTS



Internal vertebral plexus

Basivertebral veins emerge from foramina (●) in posterior vertebral bodies and drain into **internal vertebral plexus** (anterior/posterior) which drains via **intervertebral segmental veins** (with nerve roots) into **external vertebral plexuses** which, in turn connect above and below diaphragm to inferior and superior vena cavae via vertebral, azygos, lumbar and lateral sacral veins. These veins are **VALVELESS,** thus cancer cells from thyroid, breast, kidney and prostate can easily enter the bones

The **posterior longitudinal ligament** attaches to discs only and not to the vertebral bodies so that there is free drainage of the basivertebral veins

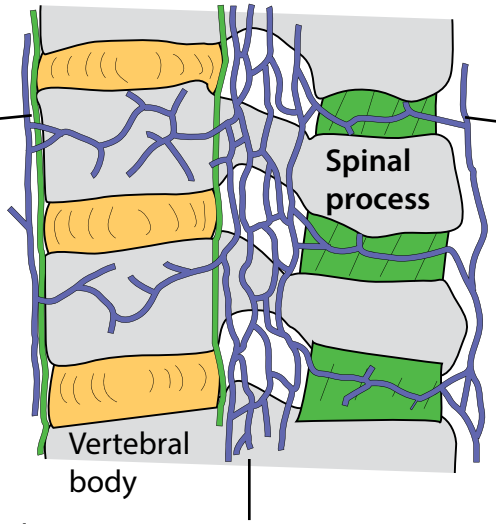


VERTEBRAL VENOUS PLEXUSES

Anterior

External venous plexus. Anterior. Drain via vertebral bodies **VALVELESS**

Drain to: cervical, azygos, ascending lumbar, lateral sacral veins



Posterior

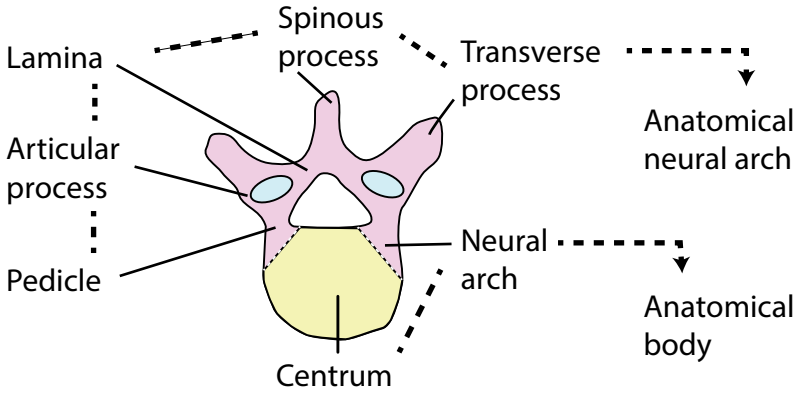
External venous plexus. Posterior to ligamentum flavum. **VALVELESS**

Drain to: intervertebral then to: vertebral, intercostal, lumbar, lateral sacral veins

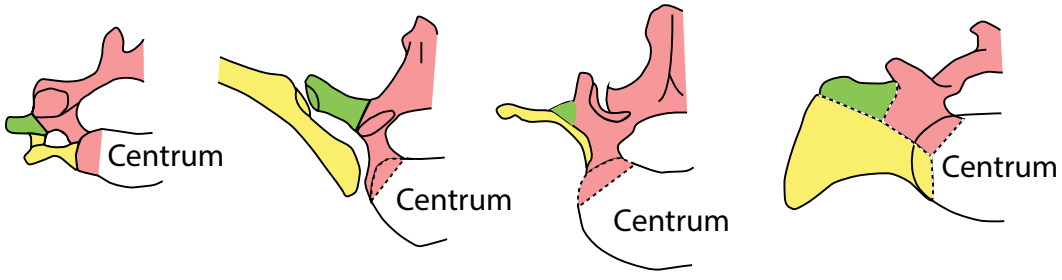
Internal vertebral veins. One set of anterior and two sets of posterior. Around dura and posterior longitudinal ligament. **VALVELESS**. Communicate above with occipital and basilar sinuses, segmentally receive veins from spinal cord and basivertebral veins

A TYPICAL VERTEBRA

Each vertebra has:
A BODY: anteriorly
A VERTEBRAL ARCH: posteriorly
Each arch has:
2 pedicles, 2 laminae, a spinous process,
a transverse process and a vertebral foramen



COSTAL ELEMENTS OF VERTEBRAE AT VARIOUS LEVELS

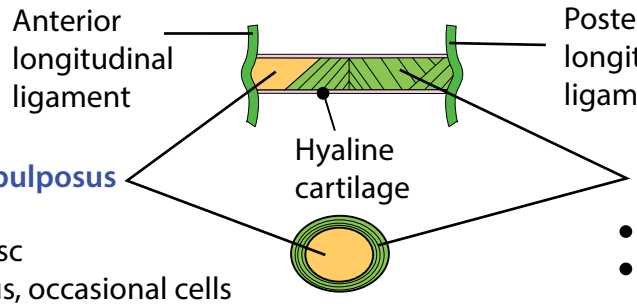


NEURAL ARCH AND ITS PROCESS
TRANSVERSE ELEMENT
COSTAL ELEMENT

INTERVERTEBRAL DISCS

Secondary cartilaginous joint

BONE ↔ HYALINE CARTILAGE ↔ FIBRO-CARTILAGE ↔ HYALINE CARTILAGE ↔ BONE



Nucleus pulposus

- 15% of disc
- Gelatinous, occasional cells
- 90% water normally
- 70% in old age
- Notochord remnant

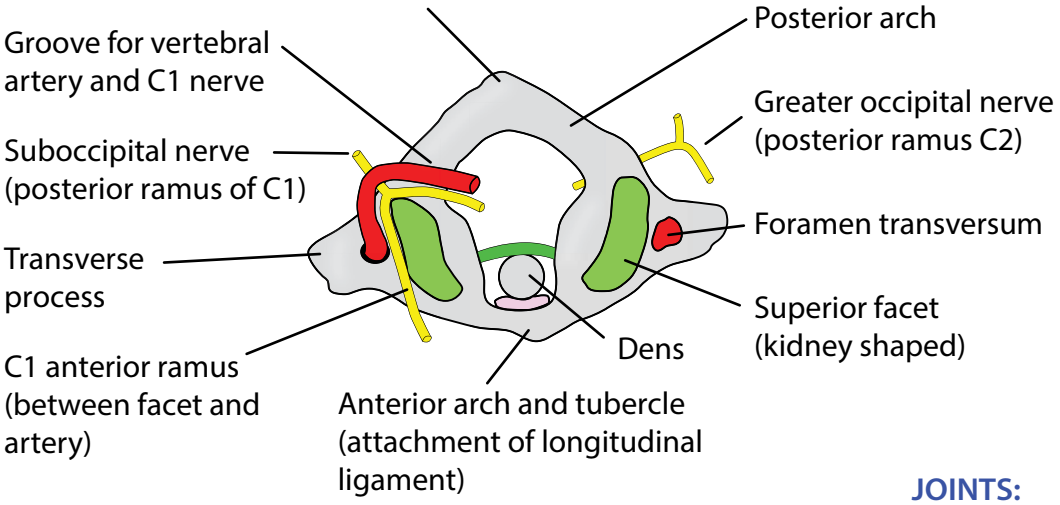
Annulus fibrosus

- Alternate angled lamellae
- Strong attachment to anterior and posterior longitudinal ligaments
- Fibrocartilage

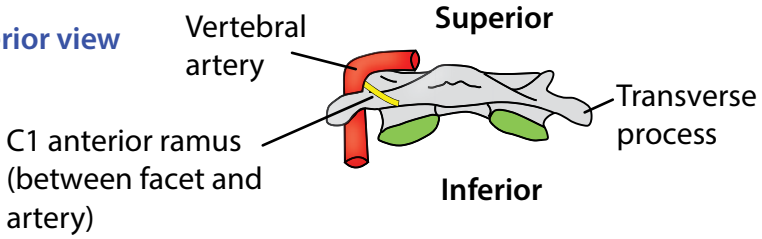
- Decreasing elasticity and increasing collagen with age
- More posterior in lumbar region
- Herniation damages nerve one below the level of prolapse

ATLAS - C1

Viewed from above



Anterior view

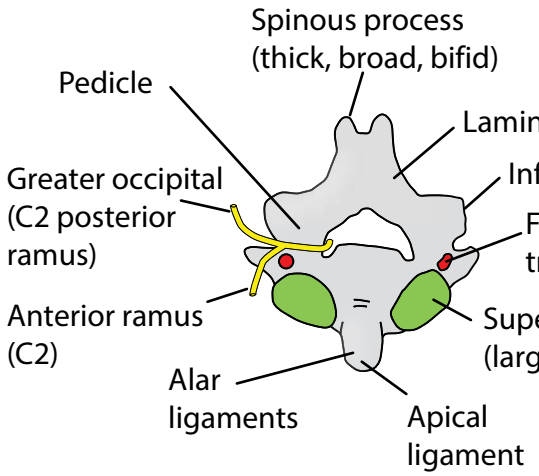


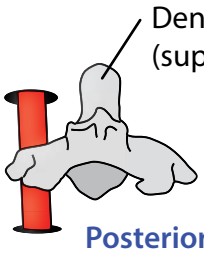
JOINTS:

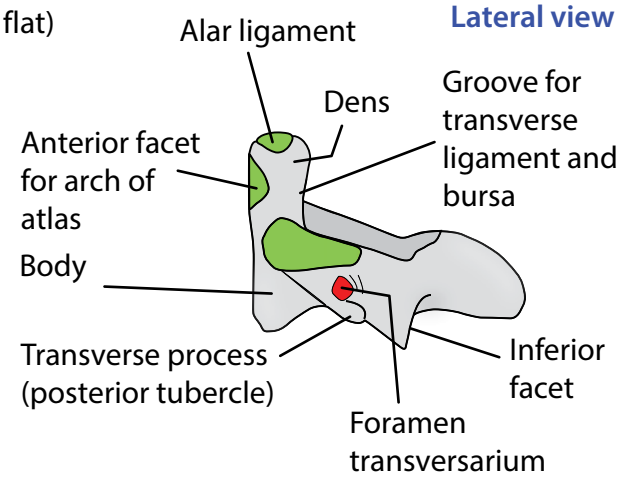
Atlanto-occipital:
Nodding movement

Atlanto-axial:
Head pivoting.
Ligaments are apical, alar, cruciform

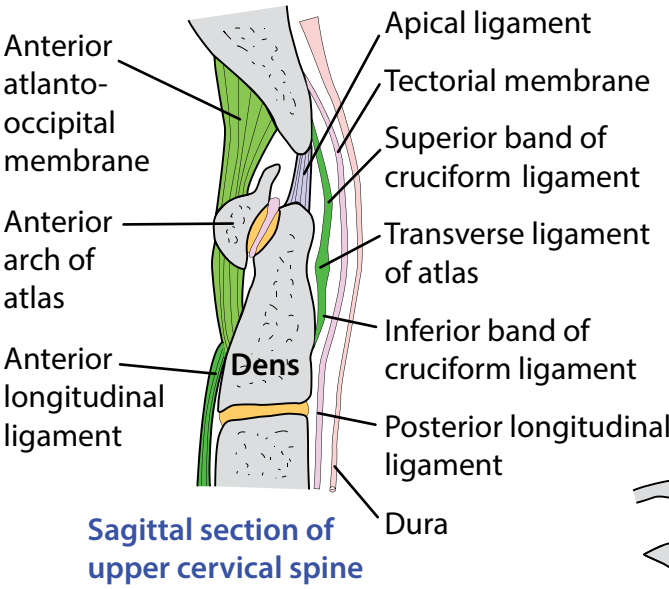
AXIS - C2



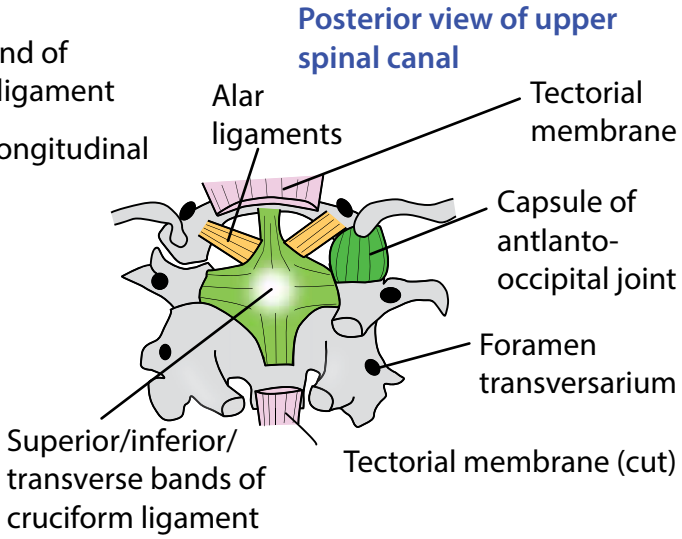




ATLANTO-AXIAL AND ATLANTO-OCCIPITAL JOINTS

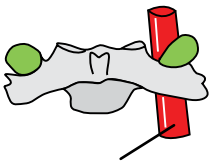


Note: The posterior longitudinal ligament becomes the tectorial membrane



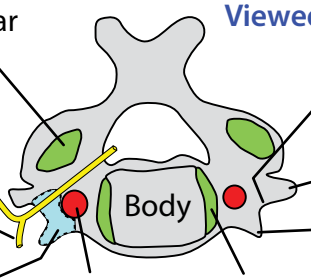
TYPICAL CERVICAL VERTEBRA

Posterior view



Vertebral artery in foramen transversarium

Viewed from above



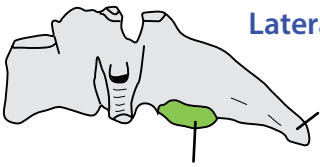
C3-6: Bifid spinous process, large triangular foramen, short wide pedicle, small body, foramen transversarium for artery, vein, sympathetic from C6 to C1

C6: Has carotid tubercle of Chassaignac (enlarged anterior tubercle over which passes the common carotid artery

C7: Vertebra prominens has long, non-bifid spinous process, foramen transversarium containing vein only.

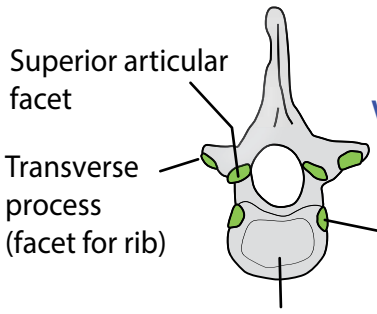
Note: The C7 nerve is above C7 vertebra and C8 nerve is below the C7 vertebra

Lateral view



THORACIC VERTEBRAE

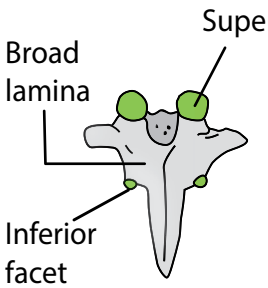
Viewed from above



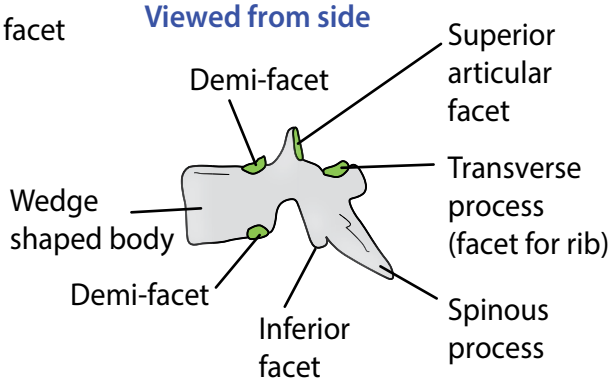
On each side of body:
T1: 1 1/2 rib facets
T2-9: 2 hemifacets
T10: 1 hemifacet
T11,12: 1 full facet

Costal element is rib plus articular facets

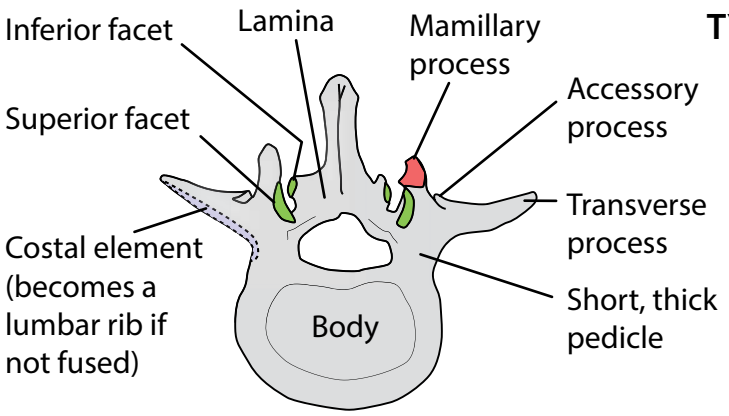
Viewed from behind



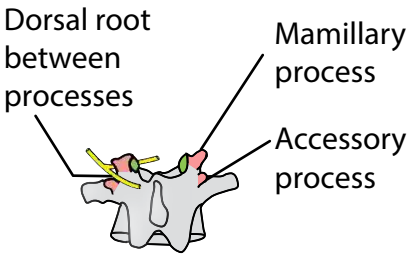
Viewed from side



TYPICAL LUMBAR VERTEBRA



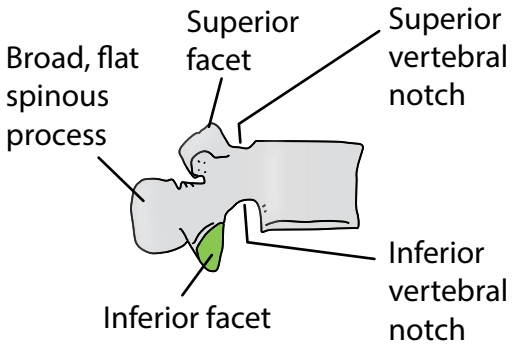
Viewed from above



Viewed from behind

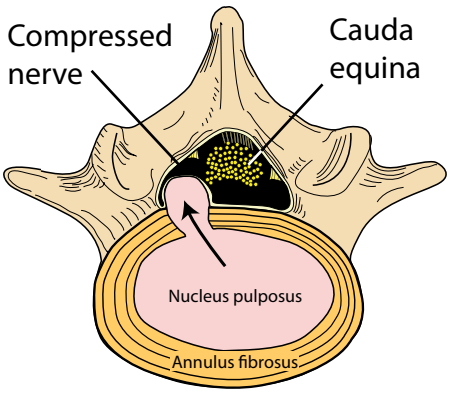
L5 viewed from above

- Wide, short pedicles
- Forward facing facets
- Thick short transverse process

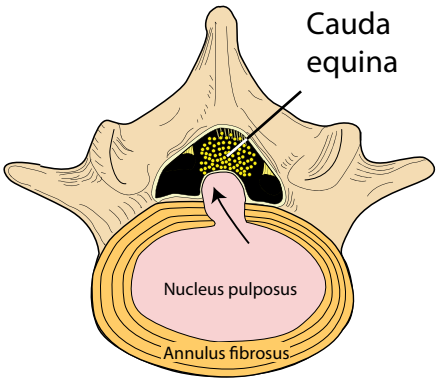


Viewed from side

POSTEROLATERAL PROLAPSED INTERVERTEBRAL DISC

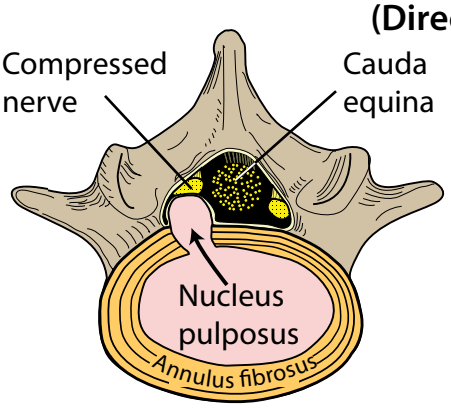


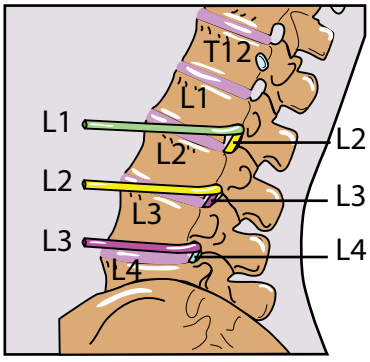
CENTRAL PROLAPSED INTERVERTEBRAL DISC

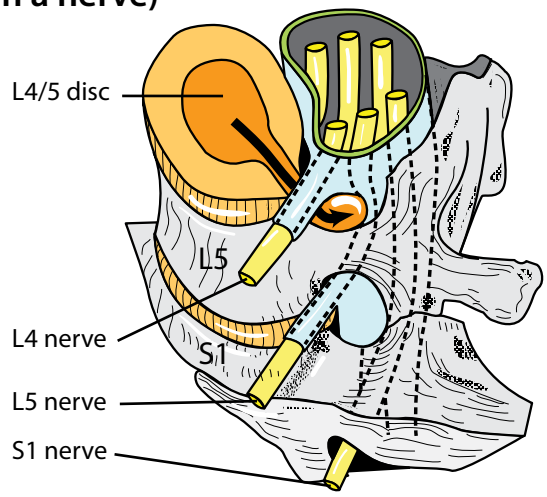


The softer **nucleus pulposus** is surrounded by a thick tough **annulus fibrosus.** The annulus weakens with age and causes it to rupture, usually posterolaterally, and the nucleus pulposus is squeezed out. Precipitating factors include bending and lifting which compress the anterior part of the disc and this pushes the nucleus pulposus posteriorly against the slightly thinner posterior wall of the annulus fibrosus.
In a **central prolapse** the cauda equina may be damaged and particularly vulnerable are the parasympathetic fibres (S2,3,4) which control bladder contraction leading to a presentation of retention of urine.

POSTEROLATERAL DISC PROLAPSE
(Direct pressure on a nerve)



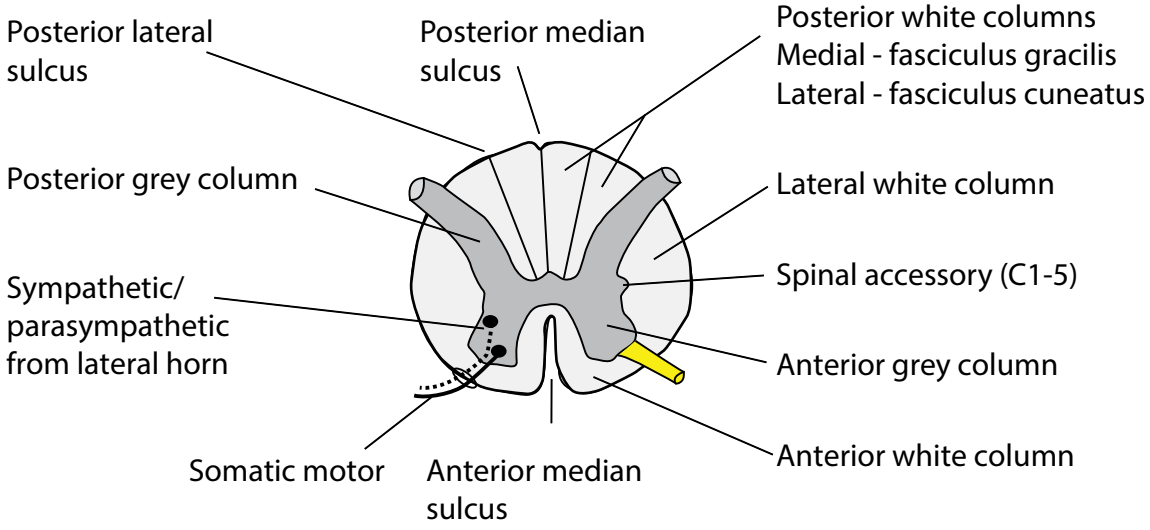




Note: As each spinal nerve emerges at the superior end of the intervertebral foramen, a prolapsing disc at that level will miss that nerve but compress the nerve that is exiting from the next foramen below.
Thus a L4/5 disc prolapes will damage the L5 nerve and usually not L4 nerve.

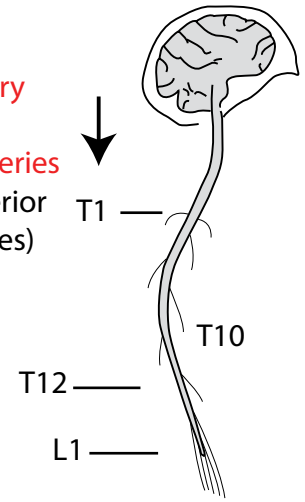
SPINAL CORD - GENERAL

- Cord begins at lower medulla of brain stem
- Cord finishes at lower border of L1 vertebra
- 45cm long in an adult
- Covered by 3 layers of meninges and CSF



BLOOD SUPPLY OF SPINAL CORD

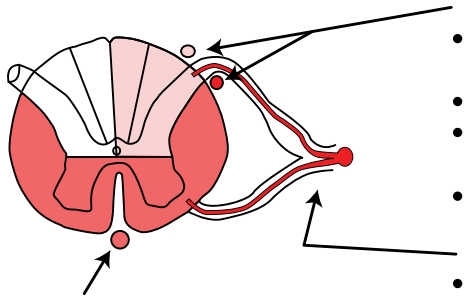
- One anterior spinal artery (from vertebral)
- Two posterior spinal arteries (from vertebral or posterior inferior cerebellar arteries)



- Ascending cervical arteries
- Deep cervical arteries
- Posterior intercostal arteries (at every level)
- Artery of Adamkiewicz
  A larger artery, usually from a left posterior intercostal artery between T9-12 (often T10)
- Lumbar arteries
- Lateral sacral arteries

All the above arteries enter via intervertebral foramina and anastomose with spinal arteries

BLOOD SUPPLY OF SPINAL CORD



POSTERIOR SPINAL ARTERIES

- Arise at foramen magnum from posterior inferior cerebellar arteries (or vertebral)
- Lie anterior and posterior to posterior rootlets
- Run length of cord but poor anastomosis except at lower end of cord
- Supply own side of grey and white posterior columns

RADICULAR (FEEDER) ARTERIES

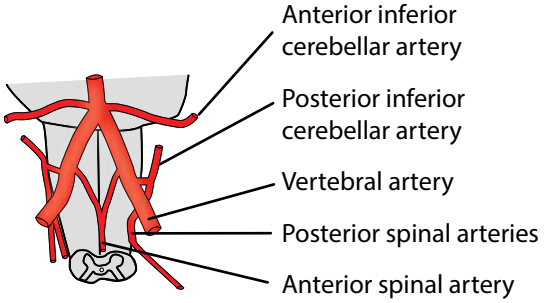
- Enter via intervertebral foramina and reinforce anterior and posterior spinal arteries and supply dorsal root ganglia
- Variable number at variable levels but largest is **Arteria Radicularis Magna**, usually at T10 or 11 (artery of Adamkiewicz)

ANTERIOR SPINAL ARTERY

- Single artery that arises from each vertebral artery at foramen magnum to run length of cord
- Usually larger than posterior spinal arteries but may be small.
- Supplies whole cord anterior to posterior grey columns, bilaterally

OTHER VESSELS

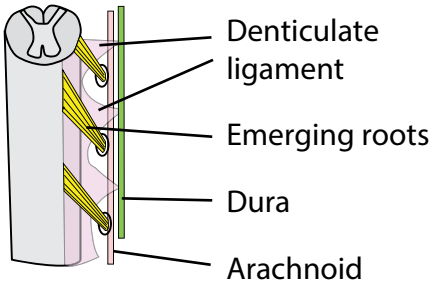
From vertebrals, deep and ascending cervicals, intercostals, lumbars and lateral sacrals. Note that all vessels anastomose under the pia mater in the periphery of the cord



SPINAL COLUMN - INTERNAL

The dural sac finishes at S2 but the **PIA MATER**, in the form of the filum terminale, continues below S2 and attaches to the back of the coccyx

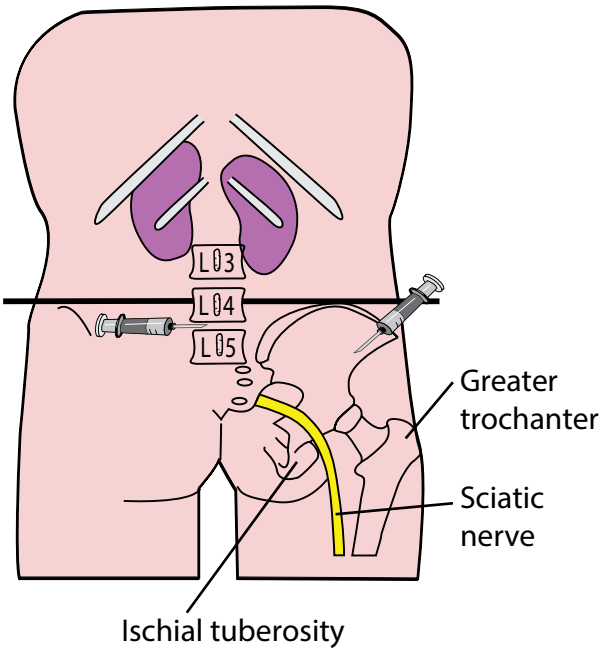
The **DENTICULATE (dentate) ligament** is pia mater that connects the cord to the dura mater laterally between the exits sites for the nerves. It pierces the arachnoid mater. Note that the spinal roots of the accessory nerve (C1-5) emerge dorsal to the denticulate ligament, whereas the sensory roots emerge dorsal and the motor roots ventral to it.



SPINAL SUBARACHNOID SPACE

- Volume 75ml
- Tapped during spinal puncture or anaesthetic below L2

POSTERIOR ABDOMEN AND BACK



Buttock injection

Intramuscular injections are given in the upper, outer (lateral) quadrant of the buttock to avoid the sciatic nerve which lies in the lower inner (medial) quadrant and passes inferiorly half way between the ischial tuberosity and the greater trochanter of the femur

Supracristal plane

A transverse line along the upper aspects of the iliac crests passing through the spinous process of the L4 vertebra. A useful aid in lumbar puncture for either the L3-4 or L4-5 spaces

PERIPHERAL NERVE INJURY

CAUSES: Direct trauma, ischaemia, traction, compression

CLASSIFICATION:

NEUROTMESIS: Complete or partial division of a nerve

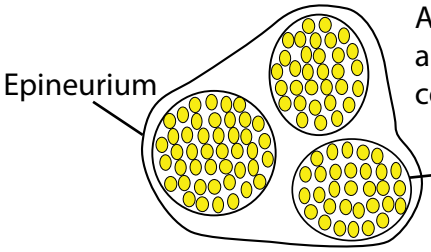
AXONOTMESIS: Interuption of the axons without interuption of the sheath

NEUROPRAXIA: Bruising or concussion of a nerve without damage to the axon or sheath leading to temporary loss of function

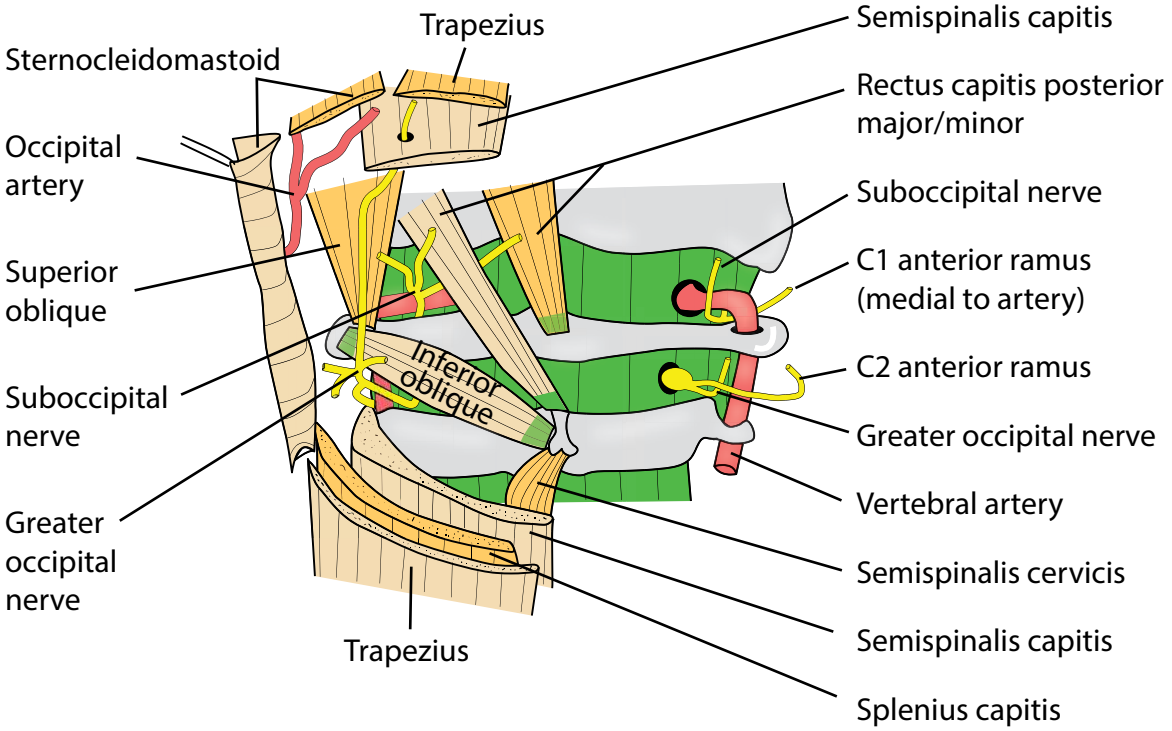
CLASSIFICATION OF MUSCLE POWER

0. No contraction
1. Flicker or trace of contraction
2. Active movement, with gravity eliminated
3. Active movement against gravity
4. Active movement against gravity and resistance
5. Normal power

STRUCTURE OF A NERVE



SUBOCCIPITAL TRIANGLE 1



SUBOCCIPITAL TRIANGLE 2

SUBOCCIPITAL NERVE

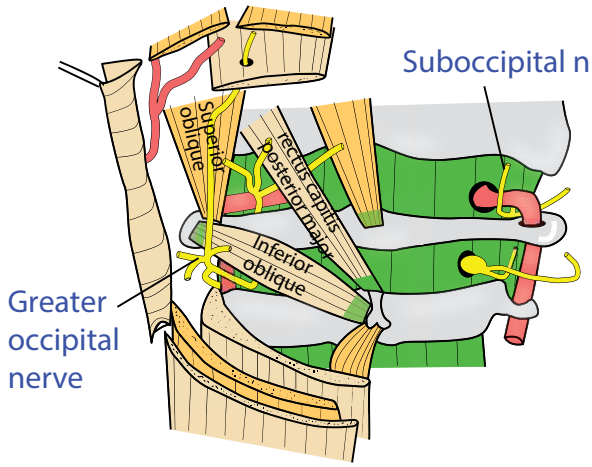
- Posterior ramus of C1
- No skin distribution
- Rectus capitis posterior major/minor
- Superior/inferior obliques
- Semispinalis capitis

GREATER OCCIPITAL NERVE

- Posterior ramus of C2
- Semispinalis capitis
- Splenius capitis
- Inferior oblique via connection to C1
- Skin of posterior scalp

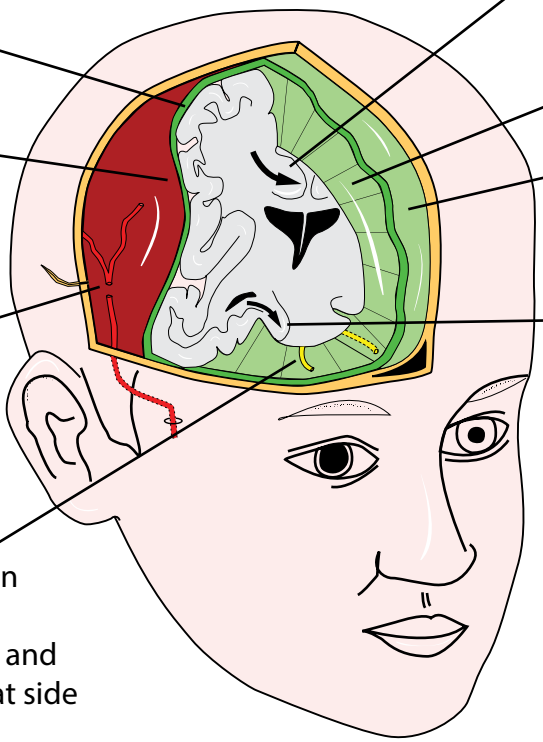
SUBOCCIPITAL TRIANGLE

Boundaries: Superior oblique, inferior oblique and rectus capitis posterior major
Floor: Posterior atlanto-occipital membrane, posterior arch of atlas
Contains: Vertebral artery and suboccipital nerve
In roof: Greater occipital nerve and occipital artery



5.3 Intracranial Haemorrhages

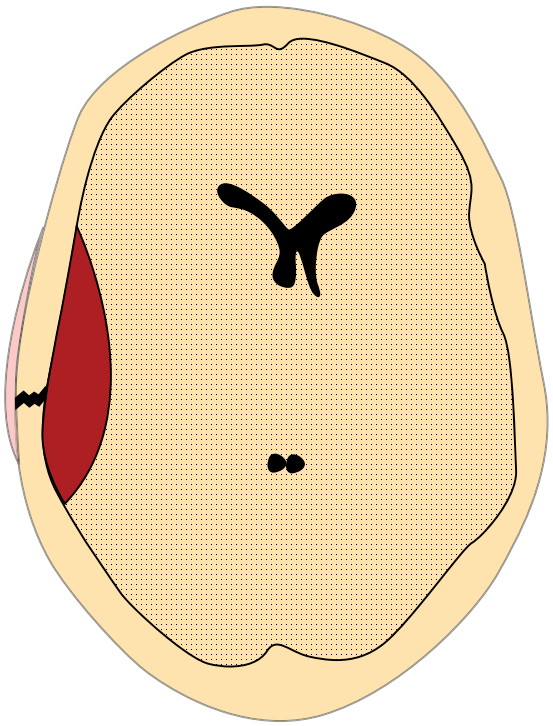
EXTRADURAL HAEMORRHAGE



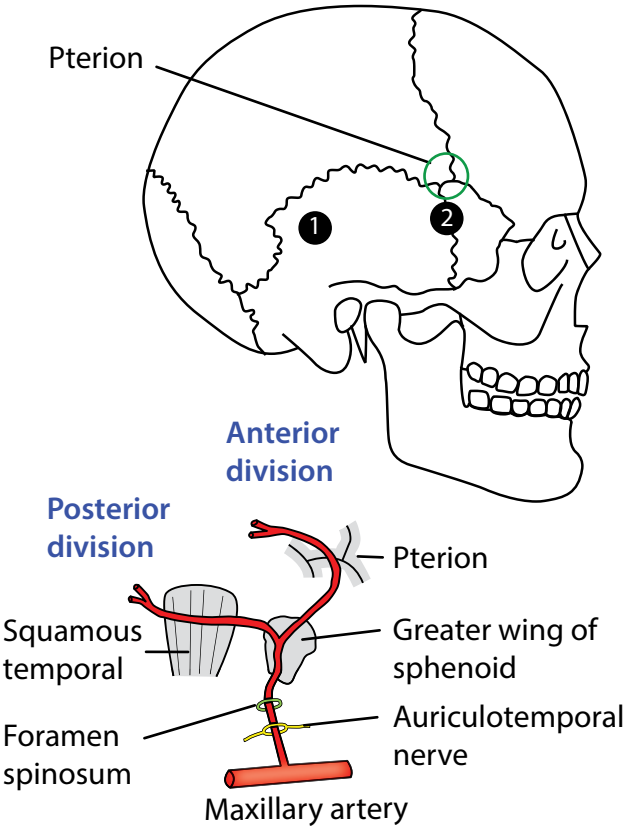
EXTRADURAL HAEMORRHAGE

Haematoma is well rounded as it is arterial pressure lifting the endosteal dura from the inside of the skull. Note the position - deep to the pterion and the soft tissue swelling superficial to the fracture over it.
The midline structures have been shifted to the opposite side

As the endosteal dura is firmly attached to bone, the arterial bleed usually takes an hour or so to produce a haematoma of sufficient size to displace the brain and thus, clinically, there is typically a latent period before symptoms and signs appear



BURR HOLES FOR EXTRADURAL HAEMORRHAGE



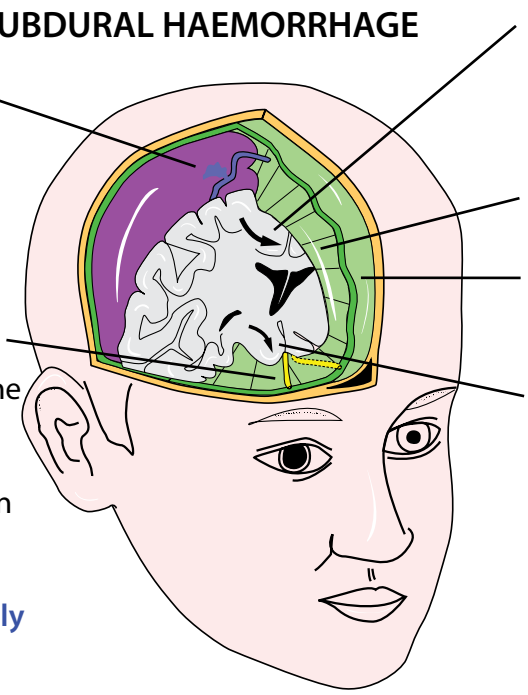
1. Surface marking for the posterior branch of the middle meningeal artery:
The crossing point of a line vertical from the mastoid process and a line horizontal from the outer canthus of the eye

2. Surface marking for the anterior branch of the middle meningeal artery:
3cm above the mid point of the zygomatic arch. (Just inferior to pterion)

SUBDURAL HAEMORRHAGE

Rupture of veins between brain and the sagittal sinus giving a haematoma beneath the dura. Shape is more diffuse and less rounded than extradural haemorrhage

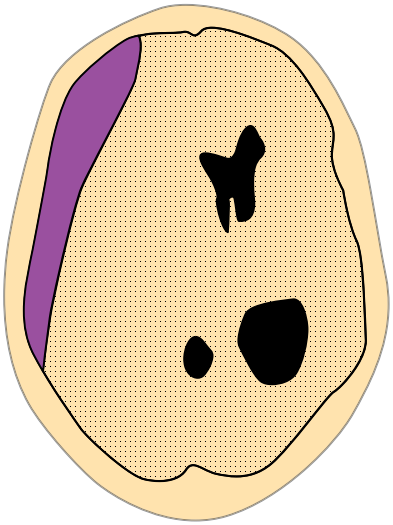
The oculomotor nerve (III) is caught on the edge of the tentorium cerebelli damaging the parasympathetic and giving a dilated pupil on that side. Damage to the motor function in III may give the patient a squint. **Displacement of the brain may lead to signs being paradoxically on the opposite side**



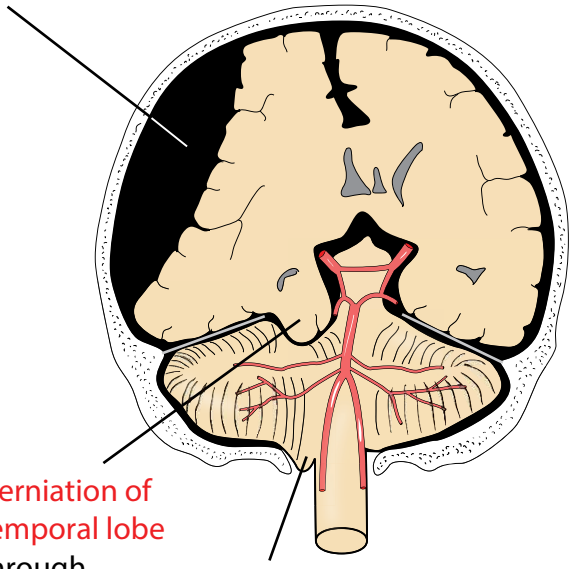
Look for Papilloedema!

As this is a venous bleed the clinical appearance of symptoms and signs may be delayed for days or even weeks. The veins are probably more likely to rupture in elderly people due to an element of brain shrinkage

SUBDURAL HAEMORRHAGE



Shift of midline and ventricles to opposite side. Haematoma is not rounded as is an extradural haemorrhage.

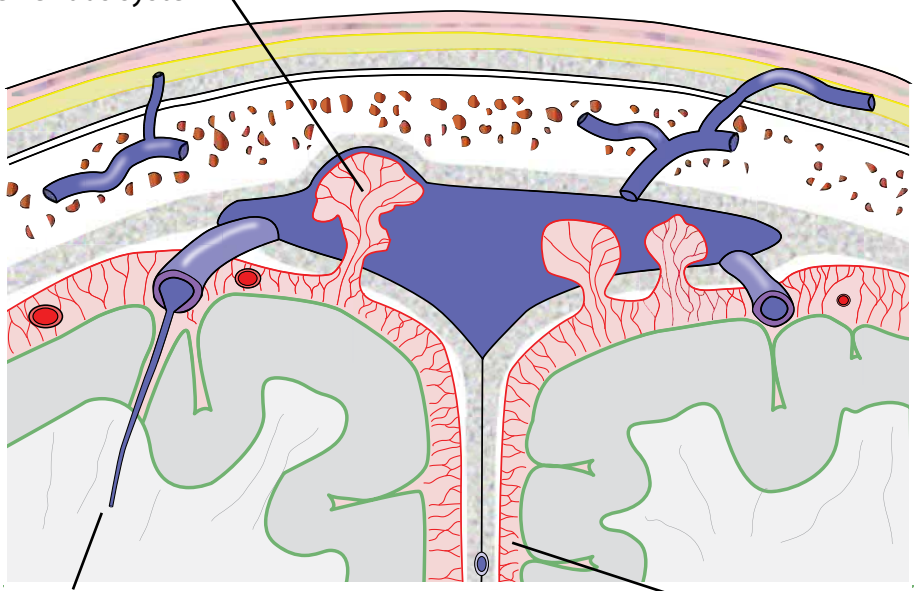


Herniation of temporal lobe through tentorium cerebelli

Herniation of cerebellar tonsil through foramen magnum. "Coning"

SUBDURAL HAEMORRHAGE RUPTURE OF CEREBRAL VEINS

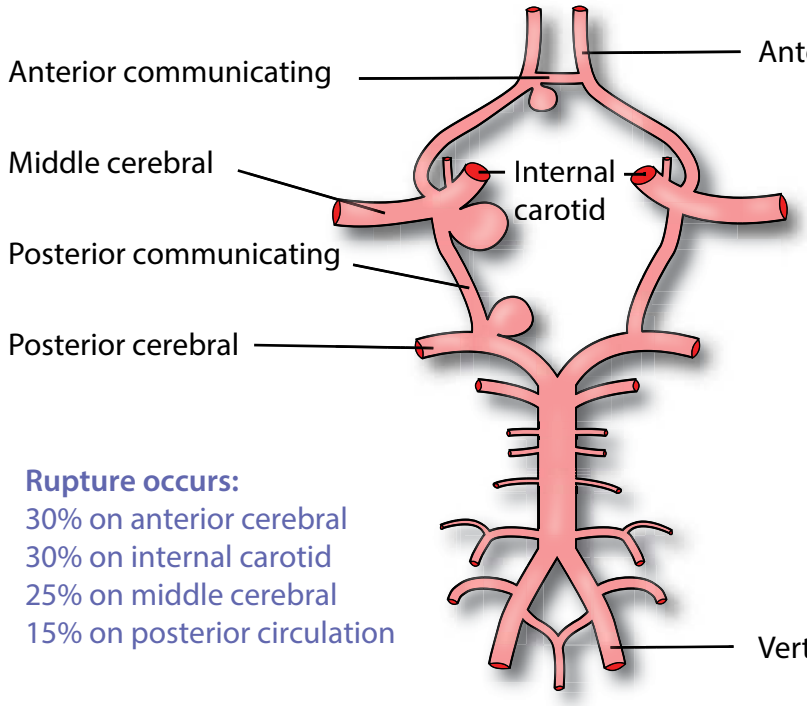
Arachnoid granulations in the **superior sagittal sinus** returning CSF to the venous system



Cerebral veins entering superior sagittal sinus. These may be torn particularly in elderly people who have a degree of brain shrinkage

Subarachnoid space

SUBARACHNOID HAEMORRHAGE
RUPTURE OF BERRY ANEURYSMS ON CIRCLE OF WILLIS



Sudden, often catastrophic arterial bleed into CSF in subarachnoid space due to rupture of a berry aneurysm on the Circle of Willis

Rupture occurs:
30% on anterior cerebral
30% on internal carotid
25% on middle cerebral
15% on posterior circulation

5.4 Cranial Nerves in General and Skull Foramina

SIMPLE CLASSIFICATION OF CRANIAL NERVES

I	OLFACTORY	Special sense	Smell
II	OPTIC	Special sense	Sight
III	OCULOMOTOR	Somatic motor	Eye movements
IV	TROCHLEAR	Somatic motor	Eye movements
V	TRIGEMINAL	Somatic sensory	Sensory
		Branchiomotor	Muscles of mastication
VI	ABDUCENT	Somatic motor	Eye movements
VII	FACIAL	Branchiomotor	Muscles of facial expression
VIII	VESTIBULOCOCHLEAR	Special sense	Hearing/balance
IX	GLOSSOPHARYNGEAL	Somatic sensory	Oropharynx
		Branchiomotor	Stylopharyneus(single muscle)
X	VAGUS	Parasympathetic	Heart to colon
		Branchiomotor (from XI)	Palate, larynx
XI	ACCESSORY	Somatic motor	Sternomastoid, trapezius
		Branchiomotor (to vagus)	To vagus
XII	HYPOGLOSSAL	Somatic motor	Tongue

FUNCTIONS OF THE CRANIAL NERVES

I OLFACTORY
- Special sense for smell

II OPTIC
- Special sense for sight

III OCULOMOTOR
- Somatic motor for muscles of eye
- Carries parasympathetic to ciliary ganglion

IV TROCHLEAR
- Somatic motor for muscles of eye

V TRIGEMINAL
- Somatic sensory for face, sinuses, eye, nose
- Branchiomotor for muscles of mastication
- Carries all postganglionic parasympathetic to end organs

VI ABDUCENT
- Somatic motor for muscles of eye

VII FACIAL
- Branchiomotor for muscles of facial expression
- Taste
- Small sensation to external ear
- Carries parasympathetic to submandibular and pterygopalatine ganglia

VIII VESTIBULOCOCHLEAR
- Special sense for hearing and balance

IX GLOSSOPHARYNGEAL
- Somatic sensory to oropharynx
- Branchiomotor for stylopharyngeus
- Taste in oropharynx
- Baroreception
- Carries parasympathetic to otic ganglion

X VAGUS
- Parasympathetic down to left of transverse colon
- Somatic sensation to ear, larynx and pharynx
- Taste in vallecula
- Baroreception
- Branchiomotor (from XI) to muscles of palate, pharynx, larynx

XI ACCESSORY
- Somatic motor to sternomastoid and trapezius
- Branchiomotor transferred to vagus (see above)

XII HYPOGLOSSAL
- Somatic motor for tongue muscles - (except palatoglossus - pharyngeal plexus (IX, X sympathetic)

CRANIAL NERVES: NUCLEI AND FIBRES

	Somatic motor (Skeletal muscle)	Branchiomotor (Special visceral)	Parasympathetic (General visceral)	General visceral sensory	Special visceral sensory	Somatic sensory (Skin & membranes)	Special senses
I							Smell Limbic system
II							Sight: lateral geniculate body
III	Nu: Oculomotor recti (sup,med,inf) inf oblique, levator palpebrae superioris		Nu: Edinger-Westphal Ganglion: Ciliary; ciliary body and muscle, sphincter pupillae				
IV	Nu: Trochlear superior oblique						
V		Nu: Motor of trigeminal muscles of mastication, mylohyoid, anterior belly digastric, tensor palati and tensor tympani				Nu: Sensory of V Mesencephalic for proprioception: Main for touch: Spinal for pain/temp for face, orbit, tongue	
VI	Nu: Abducent lateral rectus						
VII		Nu: Facial muscles of facial expression, buccinator, post belly of digastric, stylohyoid, stapedius	Nu: Superior salivary Ganglion: Pterygopalatine; and submandibular lacrimal, submandibular, and palatine glands		Nu: Solitarius Chorda tympani for taste: anterior tongue	Nu: Sensory of V some skin of external auditory meatus and tympanic membrane	
VIII							2 nu: hearing 4 nu: equilibrium
IX		Nu: Ambiguus stylopharyngeus	Nu: Inferior salivary Ganglion: Otic; parotid, glands in post tongue and oropharynx		Nu: Solitarius taste: post tongue, vallate papillae, oropharynx, baro/ chemoreceptors	Nu: Sensory of V post tongue, palate, pharynx, tonsil, middle ear	
X		Vagus carries and distributes fibres from cranial nucleus of XI	Nu: Dorsal motor of vagus cardiac and visceral muscles of thorax and abdomen	Nu: Solitarius from heart, lungs and abdo. viscera	Nu: Solitarius Taste: vallecula and epiglottis; baro/ chemoreceptors	Nu: Sensory of V skin of post/inf auricle, ext auditory meatus: pharynx and larynx	
XI	Spinal Nu: Lat roots C1-5 Sternomastoid and trapezius	Cranial Nu: Ambiguus muscles of pharynx, larynx, palate, upper oesophagus via vagus					
XII	Nu: Hypoglossal muscles of tongue except palatoglossus						

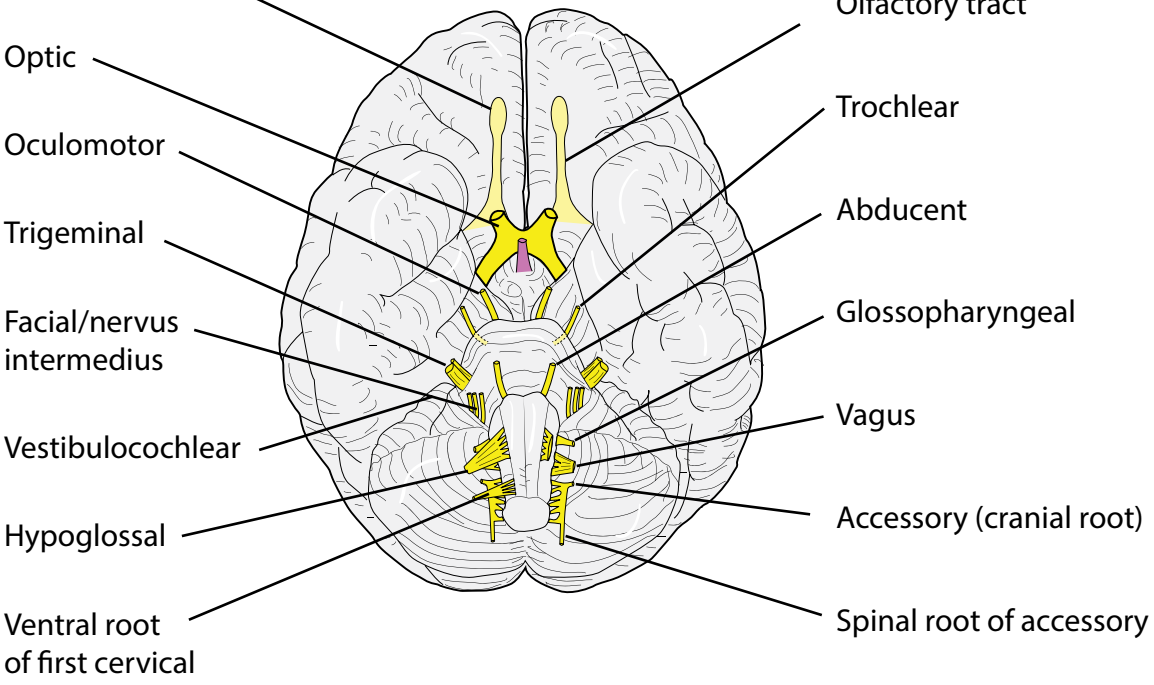
PATHWAYS OF PARASYMPATHETIC NERVES ASSOCIATED WITH CRANIAL NERVES

Cranial nerve	Central nucleus	Nerve carrying preganglionic fibres	Pathway and foramen	Site of ganglion	Name of ganglion	Nerve (V) carrying postganglionic fibres	Organs supplied
III	Edinger- Westphal (mid brain)	III via n to inferior oblique	Cavernous sinus to SOF to orbit	Between optic nerve and lateral rectus in apex of orbit	Ciliary	Nasociliary and short ciliary (Va)	Ciliary m for accommodation. Circular m of pupil for constriction
VII	Superior salivary (pons)	NI to VII to greater petrosal n to n of pterygoid canal	IAM to middle ear to MCF to pterygoid canal	Ptergyopalatine fossa	Pterygopalatine	Maxillary n brs (Vb) and zygomatico-temporal to lacrimal n (Va)	Mucosal glands of nose, nasopharynx and soft palate. Lacrimal gland
VII	Superior salivary (pons)	NI to chorda tympani to lingual n	IAM to middle ear to petrotympanic fissure to ITF	Below lingual nerve on hyoglossus	Submandibular	Lingual (Vc)	Submandibular, sublingual and ant lingual salivary glands
IX	Inferior salivary (medulla)	IX to tympanic br to lesser petrosal n	Middle ear to MCF to foramen ovale	Below foramen ovale on n to tensor tympani/palati	Otic	Auriculotemporal (Vc)	Parotid salivary gland
IX	Inferior salivary (medulla)	Pharyngeal and laryngeal branches	Direct to oropharynx and posterior third of tongue	In relevant mucosa			Mucosal glands of oropharynx and post third of tongue
X	Dorsal motor (medulla)	X - Vagus	Cardiac brs in neck then thorax and abdomen	On target organs			Viscera of thorax and abdomen down to transverse colon

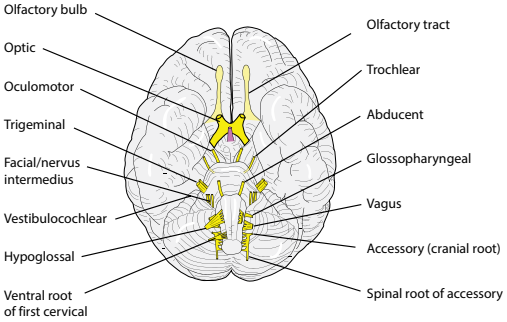
Ant = Anterior. **Br(s)** = Branch(es). **IAM** = Internal auditory meatus. **ITF** = Infratemporal fossa. **M** = Muscle:
MCF = Middle cranial fossa **N** = Nerve. **NI** = Nervus intermedius. **Post** = Posterior. **SOF** = Superior orbital fissure

CRANIAL NERVES LEAVING THE BRAIN

MOSTLY FROM BRAIN STEM
(Mid brain, pons and medulla)



CRANIAL NERVES LEAVING THE BRAIN - 1



OLFACTORY: Enters brain just anterior to midbrain in region of anterior perforating substance and septal areas. To hypothalamic region via anterior perforating substance and septal areas.

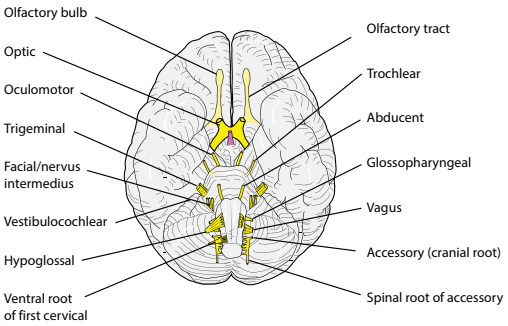
OPTIC: Enters brain just anterior to midbrain to reach lateral geniculate body, pretectal nucleus and superior colliculus for eye reflexes. To occipital cortex.

OCULOMOTOR: Emerges from brain stem, medial to cerebral peduncle.

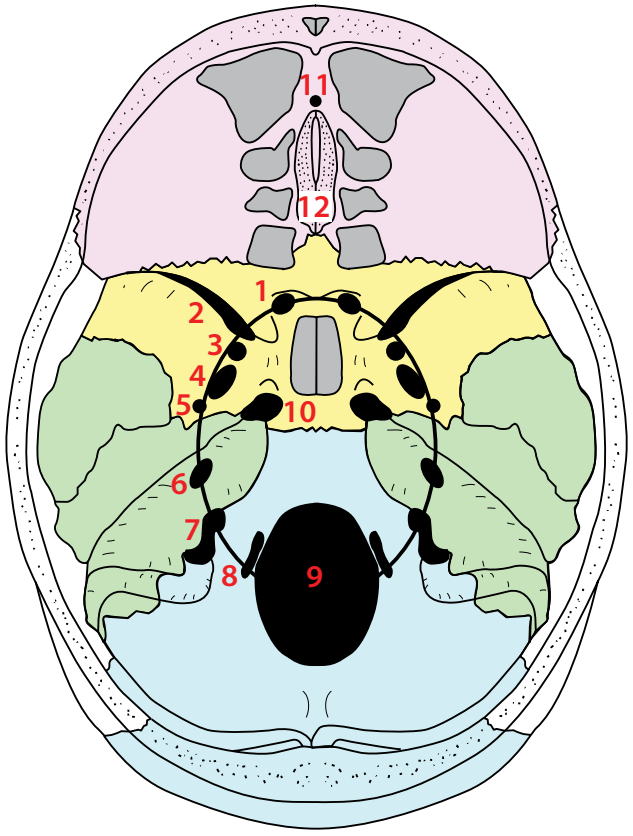
TROCHLEAR: Emeges dorsally from brain stem just below inferior colliculus and winds around cerebral peduncle just superior to pons. Pierces free edge of tentorium to enter cavernous sinus just posterior to oculomotor. (Nucleus in floor of cerebral aqueduct. Decussates just before emerging).

TRIGEMINAL: Emerges ventral surface of pons, near upper border between pons and pyramid of medulla oblongata.

CRANIAL NERVES LEAVING THE BRAIN - 2



ABDUCENT: Emerges in sulcus between pons and pyramid of medulla oblongata.
FACIAL: Emerges lower border of pons, lateral to recess between inferior olive and inferior cerebral peduncle.
VESTIBULOCOCHLEAR: Emerges in a groove between pons and medulla, posterior to facial, anterior to inferior cerebral peduncle.
GLOSSOPHARYNGEAL: Emerges as 3 or 4 rootlets from upper medulla in groove between olive and inferior cerebral peduncle, superior to vagus.
VAGUS: Emerges as 8-10 rootlets from medulla in groove between olive and inferior cerebral peduncle, below glossopharyngeal.
ACCESSORY: Emerges 4-5 rootlets from side of medulla in groove between olive and inferior cerebral peduncle, below vagus.
HYPOGLOSSAL: Emerges by 10-15 rootlets in sulcus between pyramid and olive.



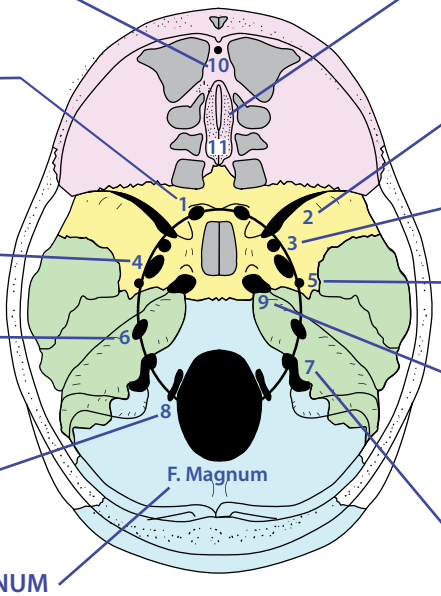
FORAMINA ON AN OVAL LINE

1 Optic canal
2 Superior orbital fissure
3 Foramen rotundum
4 Foramen ovale
5 Foramen spinosum
6 Internal acoustic (auditory) meatus
7 Jugular foramen
8 Hypoglossal canal
9 Foramen magnum

FORAMINA NOT ON OVAL LINE

10 Foramen lacerum
11 Foramen caecum (single midline)
12 Cribriform plate of ethmoid

EXIT FORAMINA BASE OF SKULL



10. FORAMEN CAECUM
Blind ended or emissary vein, start of superior sagittal sinus

1. OPTIC CANAL
Optic nerve (II), 3 layers of meninges, CSF, ophthalmic artery, sympathetics

4. FOREMEN OVALE
Vc, lesser petrosal nerve

6. INTERNAL ACOUSTIC MEATUS
VII, VIII, nervus intermedius, labyrinthine art

8. HYPOGLOSSAL CANAL
Hypoglossal nerve (XII)

FORAMEN MAGNUM
medulla/spinal cord, 3 layers of meninges, CSF, arteries: vertebral,1 anterior and 2 post spinal, spinal roots of accessory nerve (XI), tectorial membrane, apical and alar ligaments, sympathetics on arteries

11. CRIBRIFORM PLATE
Olfactory nerves in dural sheaths, anterior ethmoidal nerve and artery

2. SUPERIOR ORBITAL FISSUE
III, IV, VI, Va, superior ophthalmic vein

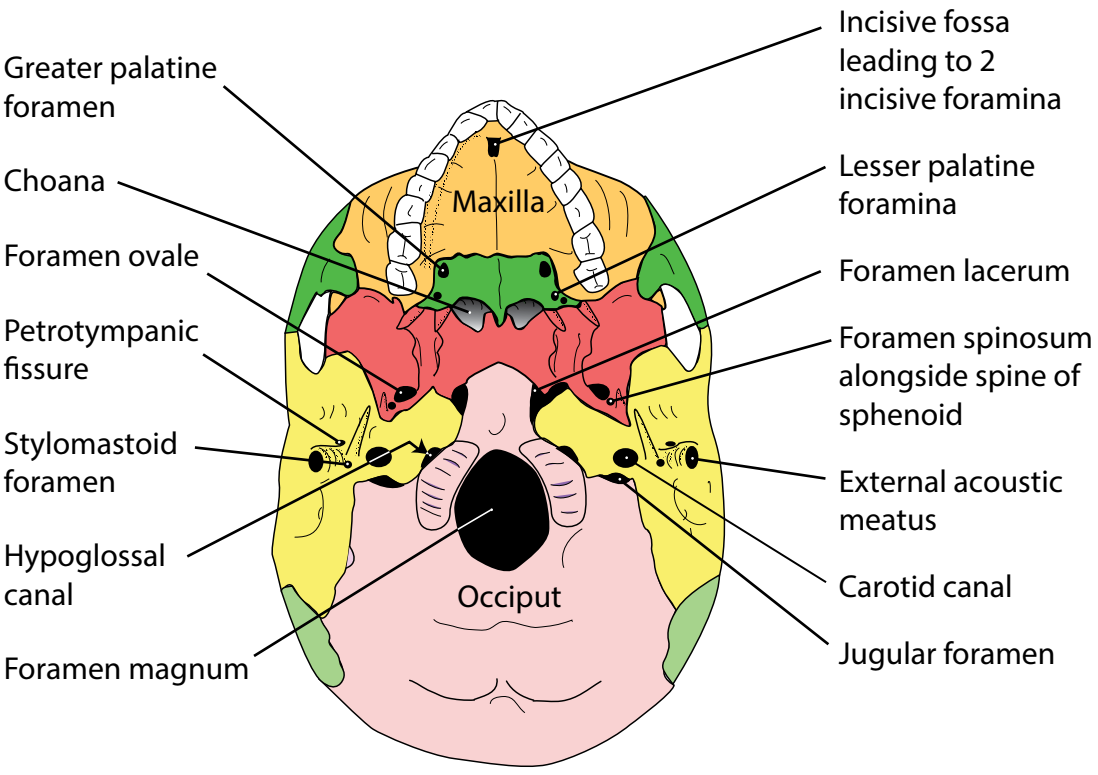
3. FORAMEN ROTUNDUM
Vb

5. FORAMEN SPINOSUM
Middle meningeal artery and sympathetics

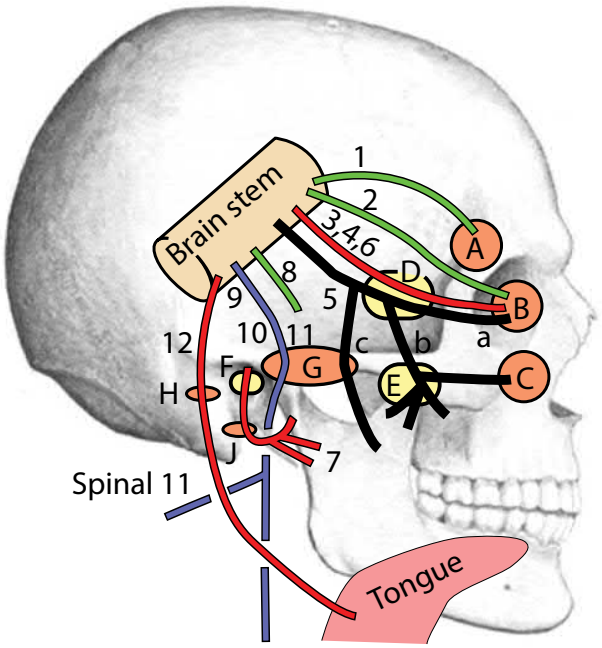
9. FORAMEN LACERUM
Nil through it but internal carotid artery exits through roof, greater and deep petrosal nerves enter pterygoid canal

7. JUGULAR FORAMEN
IX, X, XI, inferior petrosal sinus and sigmoid sinus

FORAMINA IN THE BASE OF THE SKULL



CRANIAL NERVES FROM BRAIN TO END ORGAN



The purpose of this figure is to show how some cranial nerves pass directly to their end organ (1,2,5c,8,9,10,11,12) whilst others pass through well defined cavities such as the cavernous sinus (3,4,5a,5b,6) or the pterygopalatine fossa (5b). For purposes of remembering the likely exit from the skull of cranial nerves, they can be grouped into those that pass to the nose (1), to the orbit (2,3,4,5a,6), to the front of the face (5b) and through the base of the skull (5c,7,9,10,11,12)

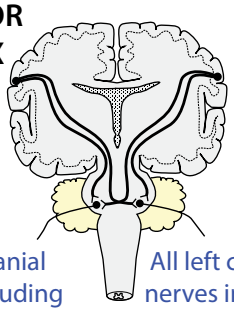
A = Nose B = Orbit C = Lower orbit
D = Cavernous sinus E = Pterygopalatine fossa
F = Middle ear G = Base of skull
H = Hypoglossal canal J = Stylomastoid foramen

RULES FOR CORTICAL CONTROL OF CRANIAL NERVES

GENERAL RULE FOR CRANIAL NERVES

R MOTOR CORTEX

L MOTOR CORTEX



All right cranial nerves including facial nerve to upper face but not to lower face (or spinal accessory to sternomastoid)

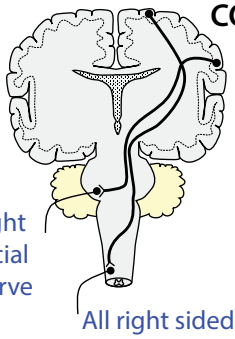
All left cranial nerves including facial nerve to upper face but not to lower face (or spinal accessory to sternomastoid)

"BILATERAL" (CONTRALATERAL AND IPSILATERAL)

1st EXCEPTION - LOWER FACE

(spinal nerves also shown as this is the norm for them)

L MOTOR CORTEX



Right Facial Nerve To Lower Face

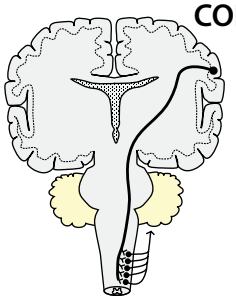
All right sided Spinal nerves

"UNILATERAL" (CONTRALATERAL)

2nd EXCEPTION - SPINAL ROOT OF ACCESSORY NERVE

(to sternomastoid)

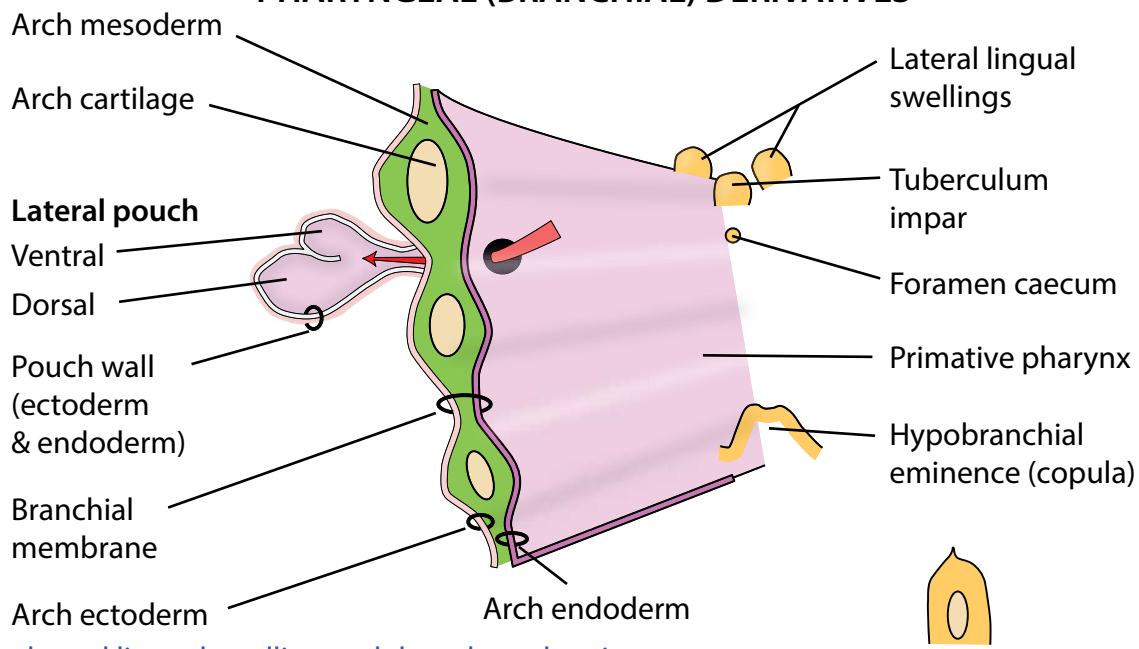
L MOTOR CORTEX



Left spinal root of Accessory nerve (C1-5) to left sternomastoid. Similarly on right

"UNILATERAL" (IPSILATERAL)

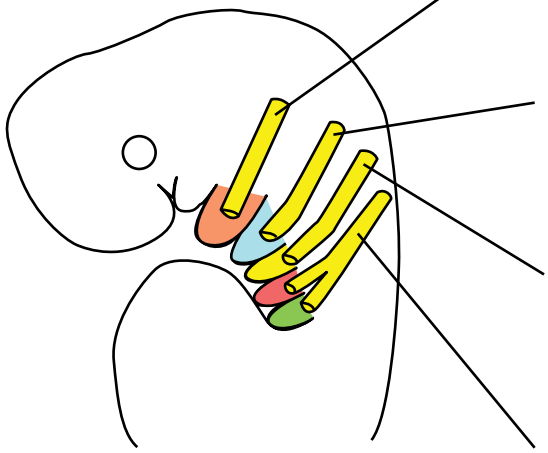
PHARYNGEAL (BRANCHIAL) DERIVATIVES



The lateral lingual swelling and the tuberculum impar from the first arch begin to form the anterior two-thirds of the tongue at 4 weeks. The copula from arches 2 and 3 forms the posterior third of the tongue

Furcula (opposite arches 4 and 6) gives epiglottis and arytenoid cartilages

BRANCHIAL ARCH NERVES

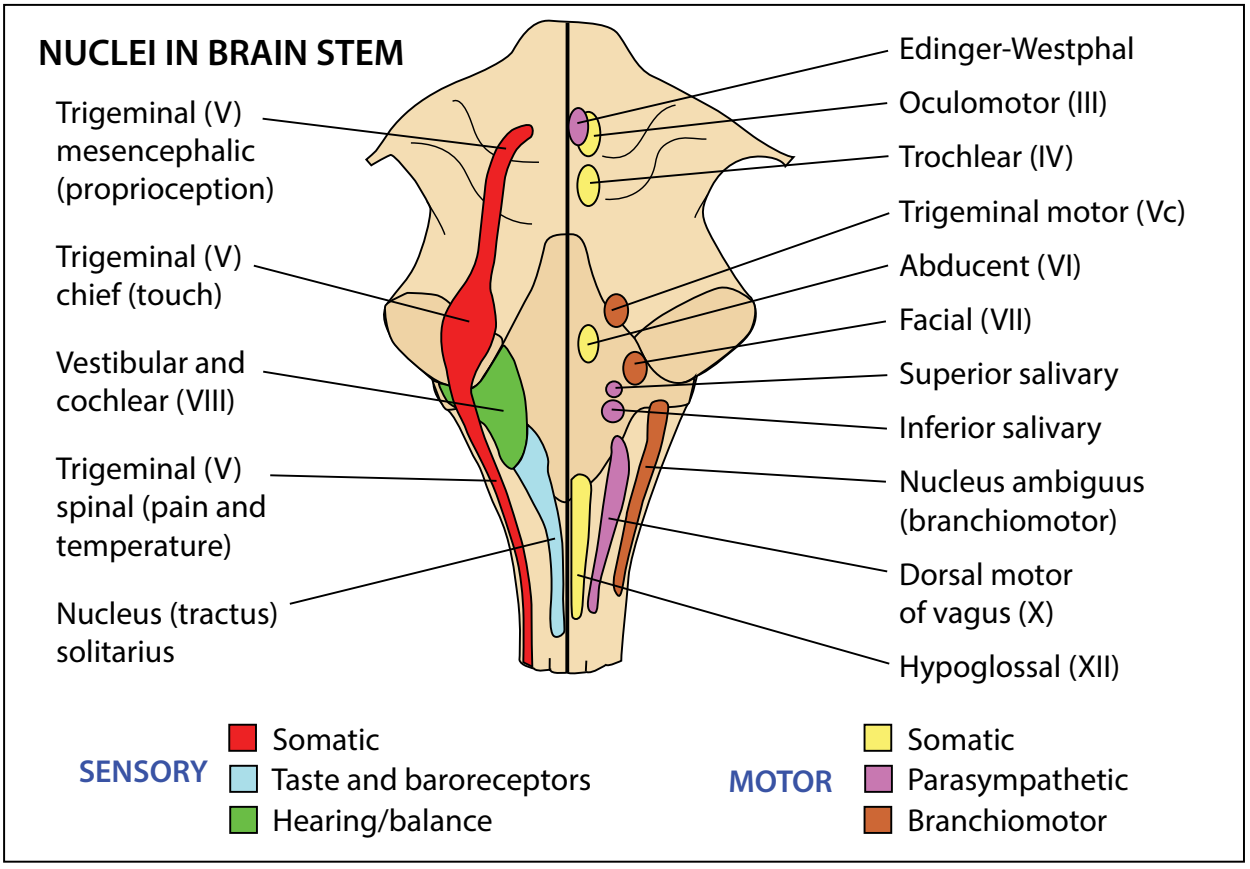


ARCH 1
Mandibular div of V
(Muscles of mastication)

ARCH 2
Facial N
(Muscles of facial expression)

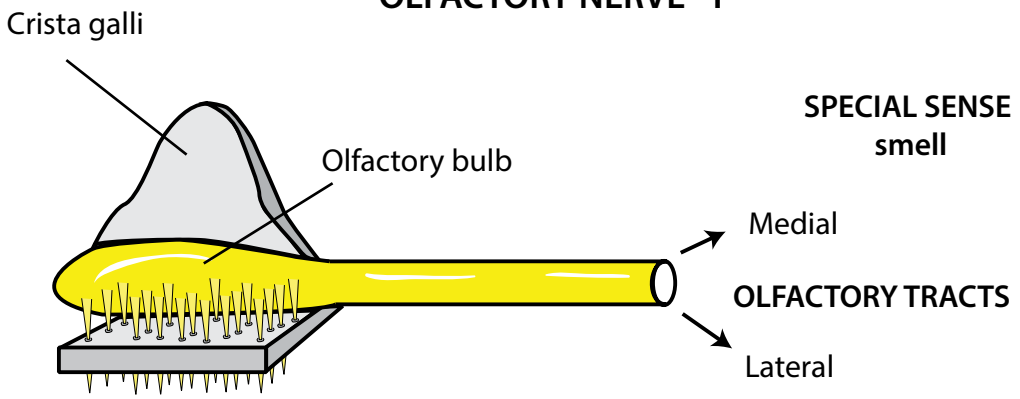
ARCH 3
Glossopharyngeal N
(Stylopharyngeus)

ARCHES 4 AND 6
Vagus N
(Muscles of palate, pharynx, larynx)


NUCLEI IN BRAIN STEM
Trigeminal (V) mesencephalic (proprioception)
Trigeminal (V) chief (touch)
Vestibular and cochlear (VIII)
Trigeminal (V) spinal (pain and temperature)
Nucleus (tractus) solitarius
Edinger-Westphal
Oculomotor (III)
Trochlear (IV)
Trigeminal motor (Vc)
Abducent (VI)
Facial (VII)
Superior salivary
Inferior salivary
Nucleus ambiguus (branchiomotor)
Dorsal motor of vagus (X)
Hypoglossal (XII)
SENSORY
Somatic
Taste and baroreceptors
Hearing/balance
MOTOR
Somatic
Parasympathetic
Branchiomotor

5.5 Cranial Nerves I, V, VII

OLFACTORY NERVE - I



20 OLFACTORY NERVES

Under surface of cribriform plate, upper medial and lateral nose

As each nerve passes through the cribriform plate, it takes a small extension of the meninges with it and thus a fracture of the base of the skull can lead to CSF rhinorrhoea

NUCLEI

- Anterior olfactory (in posterior bulb)
- Anterior perforating substance and uncus (both in the brain)

FIBRES IN, AND CARRIED BY, THE FACIAL NERVE - VII

Main Nerve

MOTOR: Muscles of facial expression plus 4 more muscles: stapedius, stylohyoid, posterior belly of digastric and occipitalis

In Nervus Intermedius

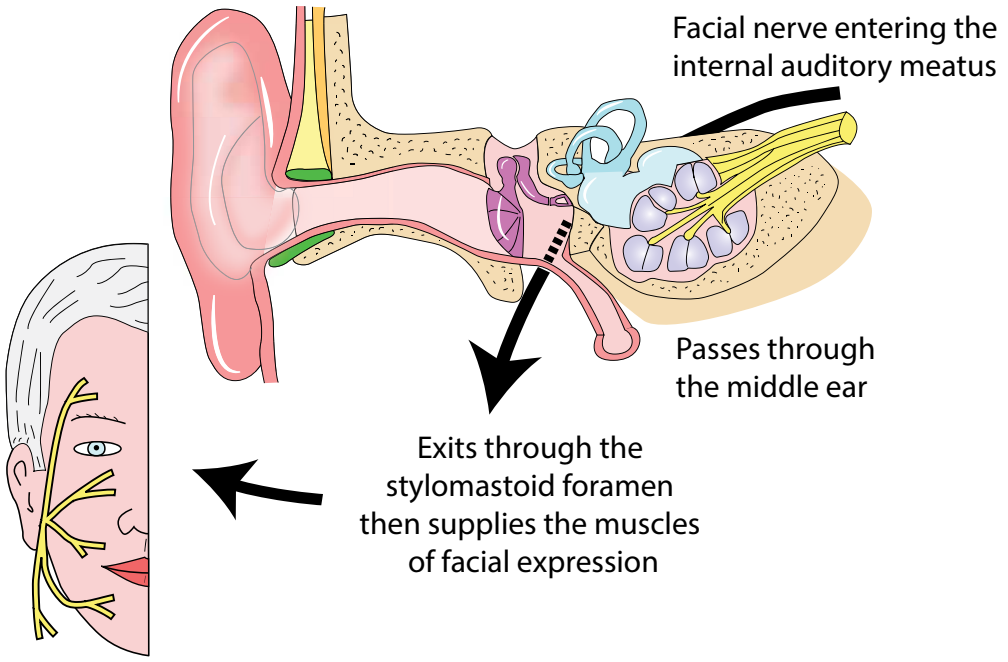
PARASYMPATHETIC: Secretomotor fibres from the superior salivary nucleus to be carried in the greater petrosal nerve for "hayfever glands" and in chorda tympani for the submandibular and sublingual glands.

TASTE: In greater petrosal nerve from the palate. In chorda tympani from the anterior 2/3 of tongue. Cell bodies in geniculate ganglion

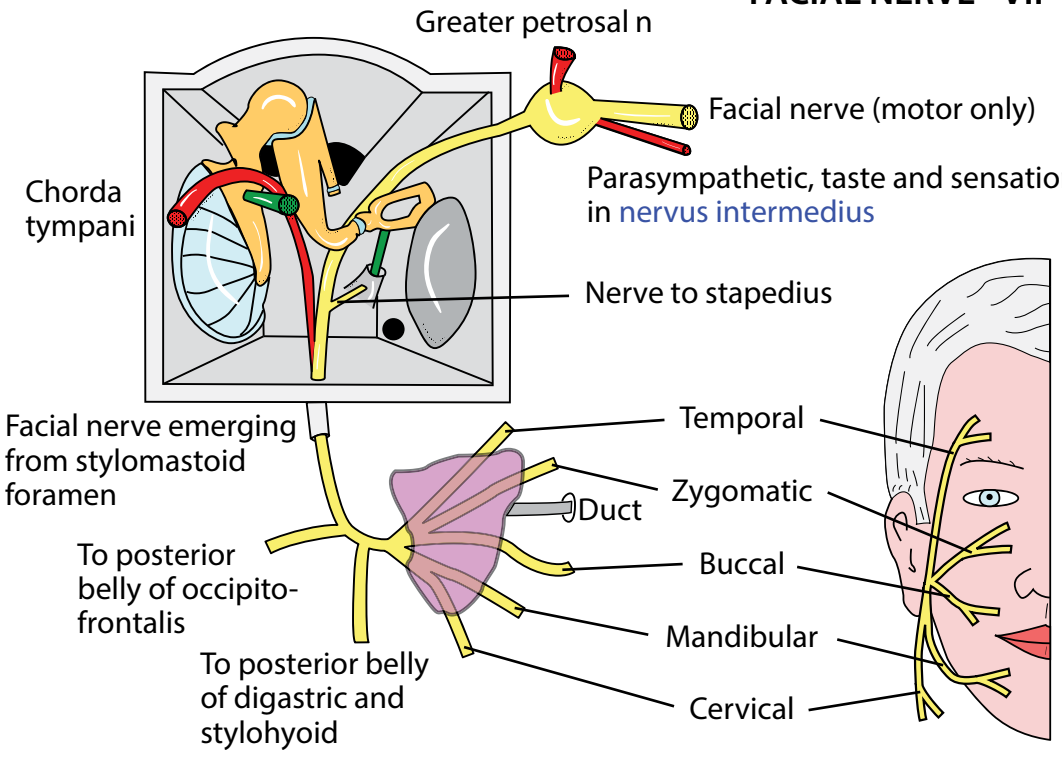
SOMATIC SENSORY: Small area of skin in external auditory meatus and drum. (Ramsey Hunt Syndrome - recrudescence of varicella (chickenpox virus) giving herpes zoster/shingles). Cell bodies in geniculate ganglion

RIGHT FACIAL NERVE - VII

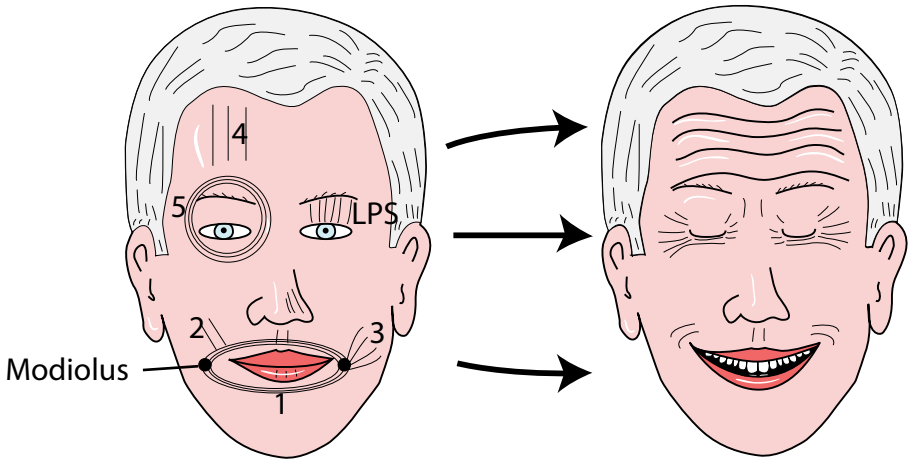
(in its simplest form to muscles of facial expression)



FACIAL NERVE - VII



MUSCLES OF FACIAL EXPRESSION

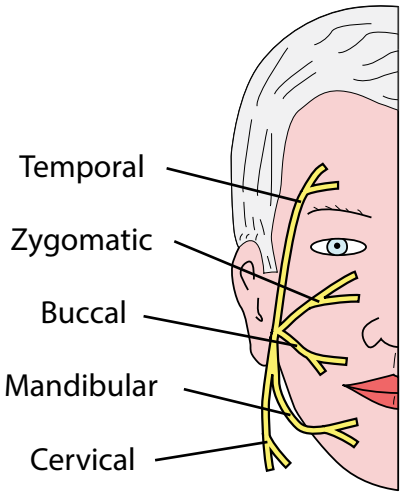


1. Close lips - obicularis oris. Facial (VII)
2. Smile - risorius, levator anguli oris Facial (VII)
3. Blow out cheeks - buccinator Facial (VII)
4. Wrinkle forehead - Frontalis Facial (VII)
5. Close eyes - obicularis oculi Facial (VII)

Note: Eyes are opened by levator palpebrae superioris (LPS), not a muscle of facial expresssion (Oculomotor and sympathetic)

FACIAL NERVE: MOTOR SUPPLY TO MUSCLES OF FACIAL EXPRESSION

Facial nerve branches:
Temporal: Frontalis and procerus
Zygomatic 1: Eye and around orbit
Zygomatic 2: Mid face and smile
Buccal: Buccinator and upper lip
Mandibular: Lower lip and orbicularis oris
Cervical: Platysma
(Note: Proprioception is supplied by trigeminal)



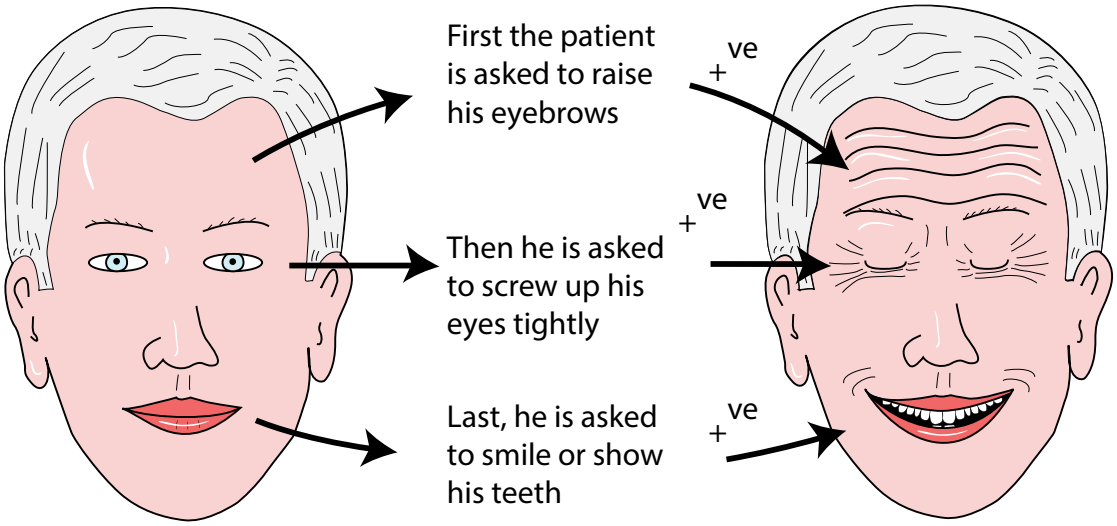
Mnemonic:
Two
Zebras
Befriended
My
Cat

Bell's Palsy
- Lower motor neurone
- All branches equally affected
- Variable recovery
- Unilateral

Stroke
- Upper motor neurone
- Lower face worse due to unilateral innervation

TESTING FOR FACIAL NERVE ACTION IN A NORMAL PATIENT - 1

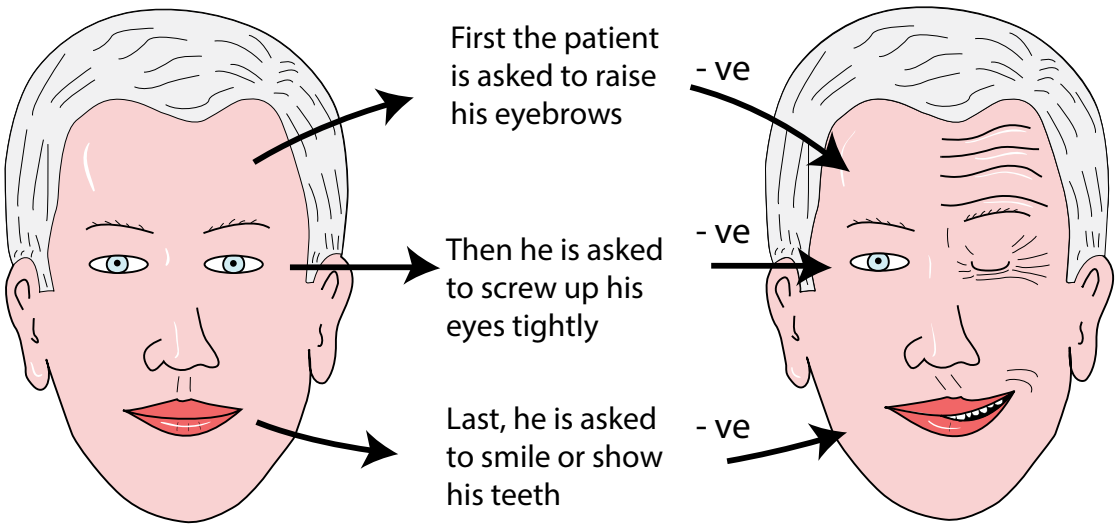
3 functions are tested separately in turn:



ALL MOVEMENTS ARE NORMAL AND SYMMETRICAL

TESTING FOR FACIAL NERVE ACTION - 2

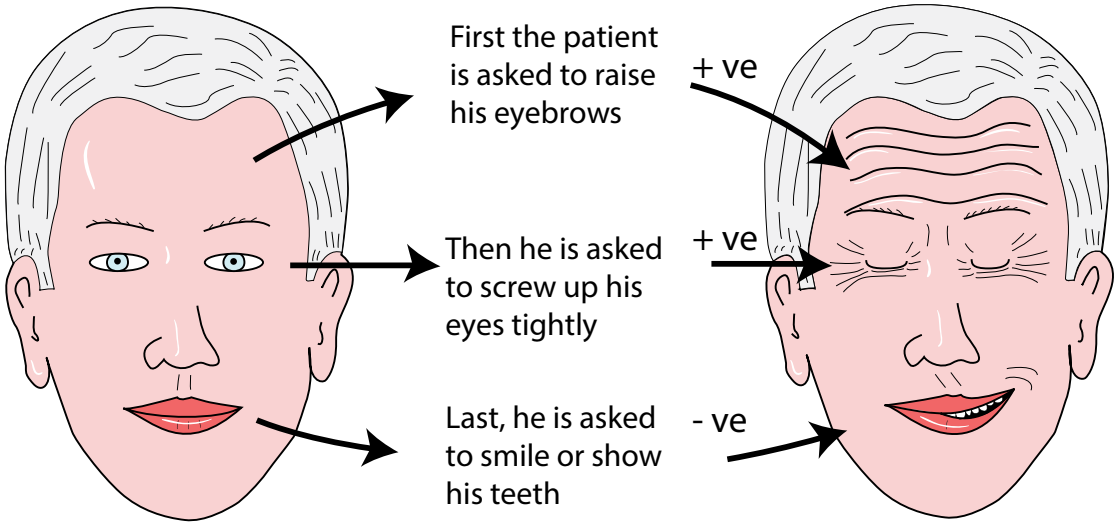
3 functions are tested separately in turn:



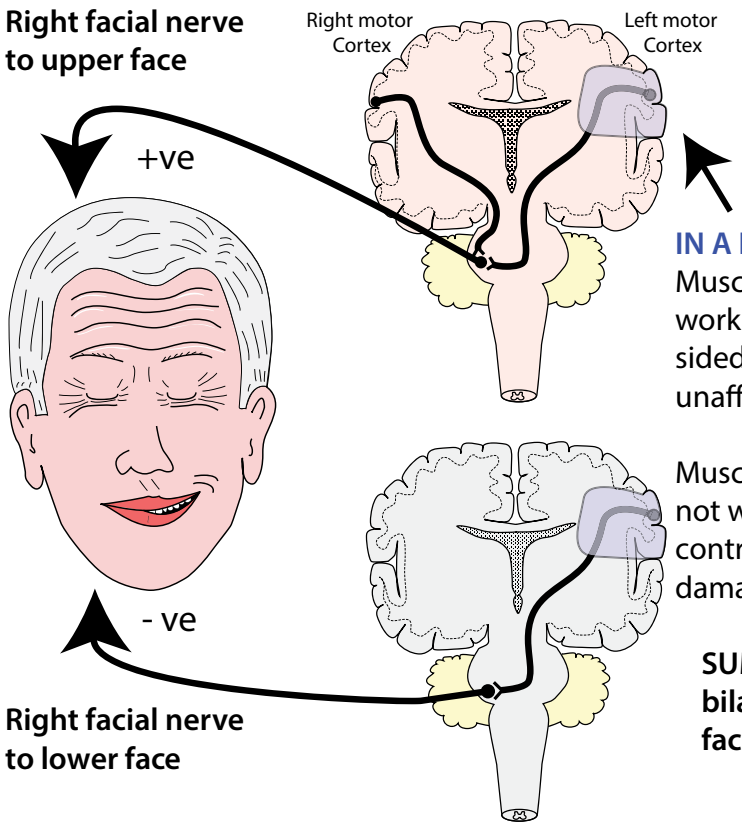
ALL MOVEMENTS ARE MISSING IN THE RIGHT SIDE OF THE FACE INDICATING A "LOWER MOTOR LESION"
TYPICALLY A BELL'S PALSY

TESTING FOR FACIAL NERVE ACTION - 3

3 functions are tested separately in turn:



MOVEMENTS OF UPPER FACE ARE NORMAL AND SYMMETRICAL BUT NO MOVEMENT IN LOWER FACE INDICATES AN **"UPPER MOTOR LESION"** **TYPICALLY A STROKE**



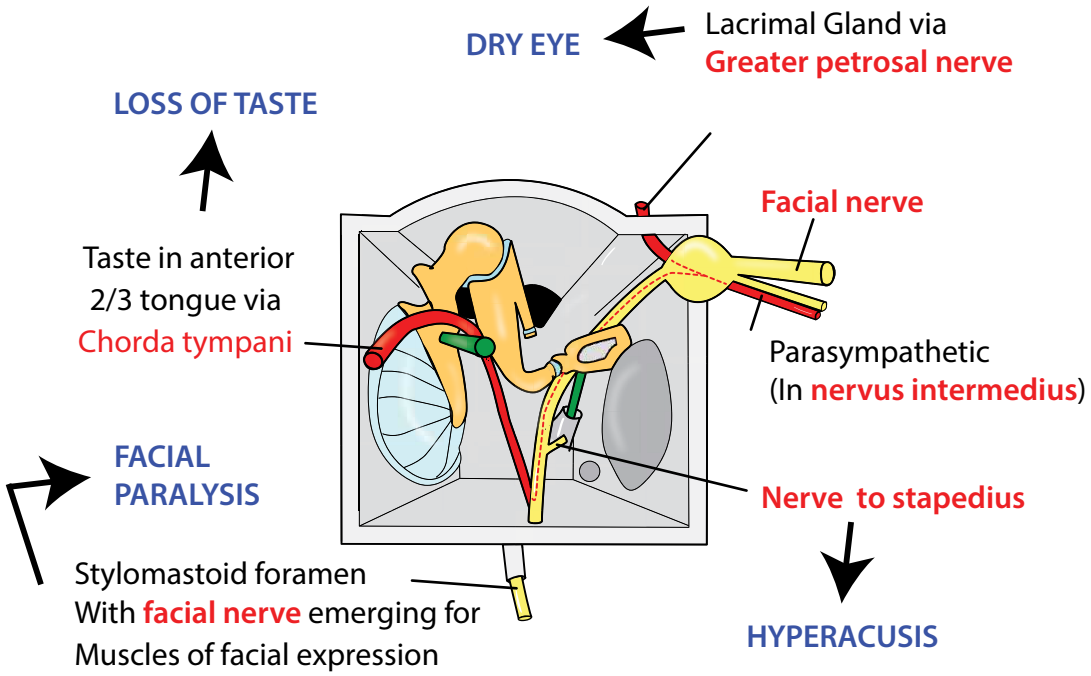
UPPER MOTOR NEURONE (SUPRANUCLEAR) FACIAL NERVE LESION

IN A LEFT SIDED STROKE:
Muscles of the **upper right face** are working normally as there is also right sided (ipsilateral) cortical control unaffected by stroke.

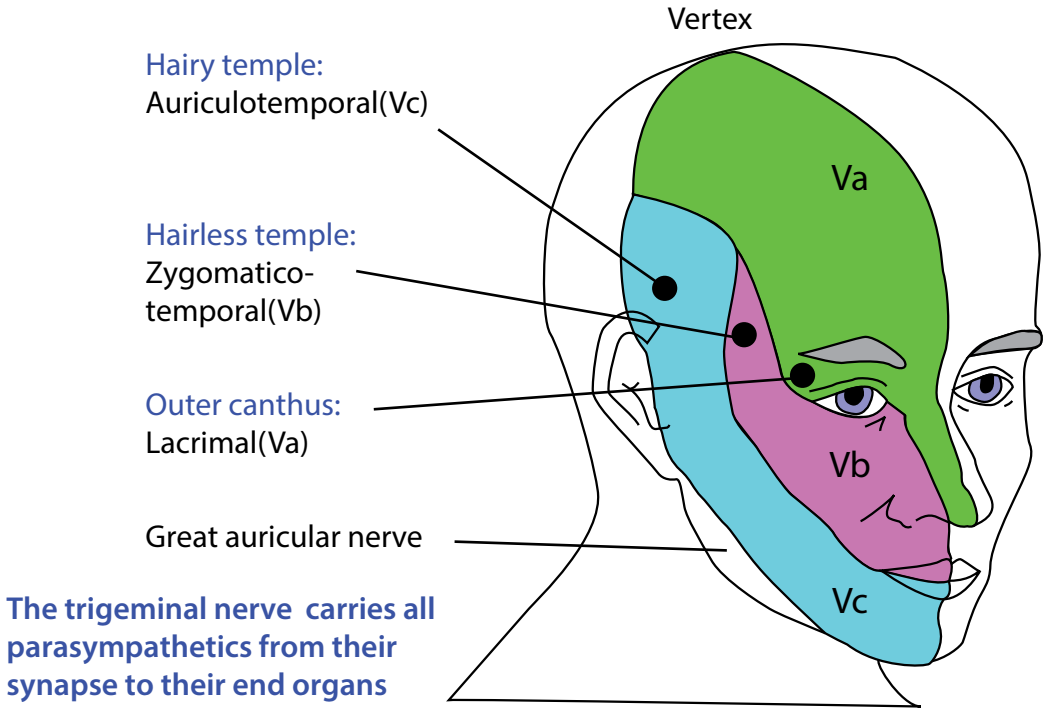
Muscles of the **lower right face** are not working as control is unilateral, contralateral only from the left damaged cortex.

SUMMARY: The upper face has bilateral control and the lower face unilateral control

SYMPTOMS AND SIGNS RELATED TO SITE OF LESION IN FACIAL NERVE - VII

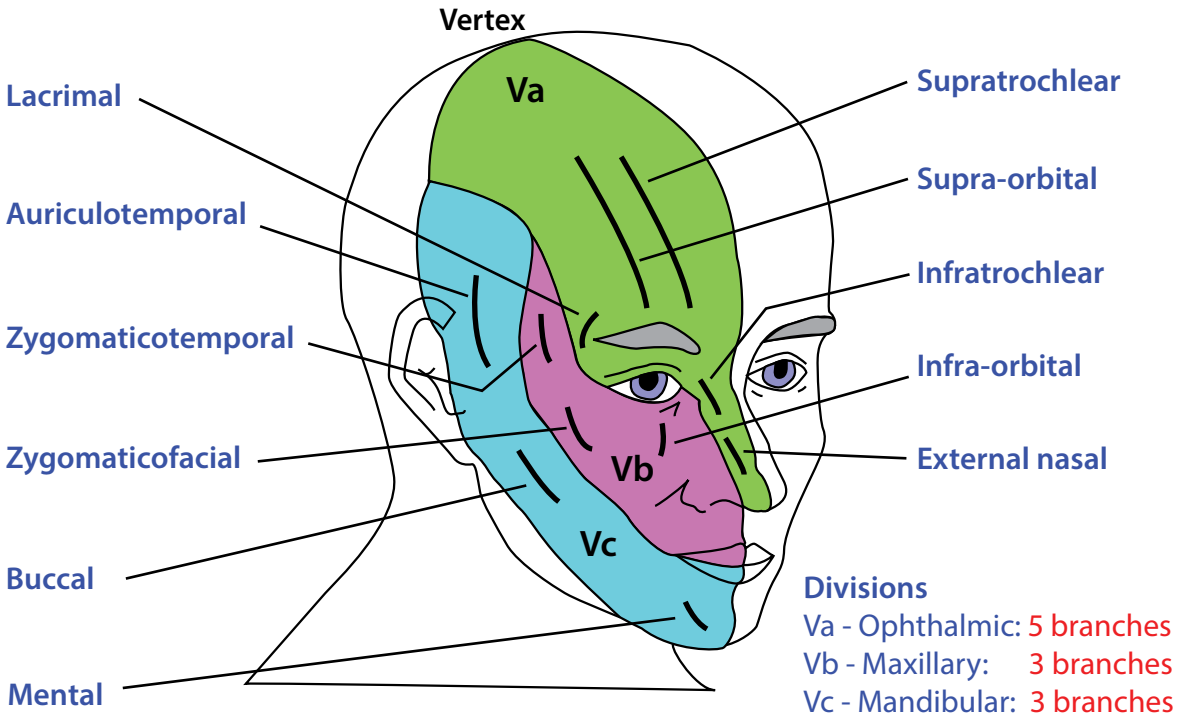


SENSORY DIVISIONS ON FACE OF TRIGEMINAL NERVE - V



The trigeminal nerve carries all parasympathetics from their synapse to their end organs

SENSORY DIVISIONS ON FACE OF TRIGEMINAL NERVE - V



TRIGEMINAL NERVE - V
(Extra notes)

- Nerve of the first pharyngeal arch
- 3 nuclei in brain stem (see below)
- Somatic but carries parasympathetic and sympathetic
- Mostly sensory but small motor branch in mandibular division
- Motor is branchiomotor (special visceral motor)
- All cell bodies are in the trigeminal ganglion EXCEPT for proprioception and these are in the mesencephalic nucleus in the brain stem

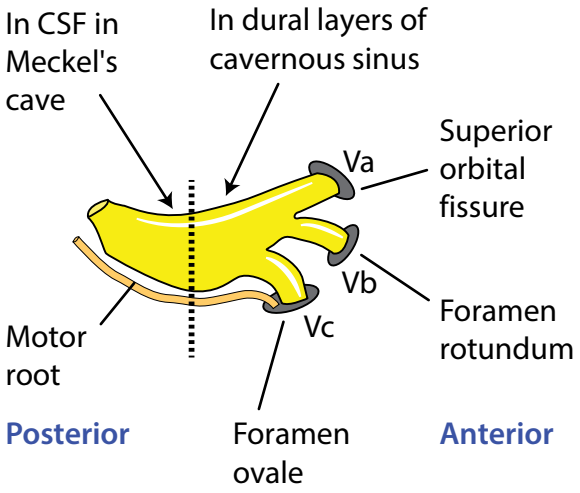
MESENCEPHALIC NUCLEUS — Proprioception from muscles of mastication, face, orbit, tongue and temporomandibular joint

MAIN SENSORY NUCLEUS — Touch and fine sensation

SPINAL NUCLEUS — Pain and temperature

TRIGEMINAL GANGLION

- Posteriorly the ganglion is in Meckel's cave surrounded by CSF then anteriorly it is beneath the dura of the cavernous sinus
- The motor root runs beneath ganglion and exits foramen ovale with the lesser petrosal nerve and accessory meningeal artery, a branch of the maxillary, which supplies the ganglion as do branches of the internal carotid in the cavernous sinus
- The ganglion contains the sensory cell bodies



TRIGEMINAL NERVE - Vc - MOTOR FIBRES IN MANDIBULAR DIVISION

Muscles of mastication

Close the mouth

- Temporalis
- Masseter
- Medial pterygoid

Opens the mouth

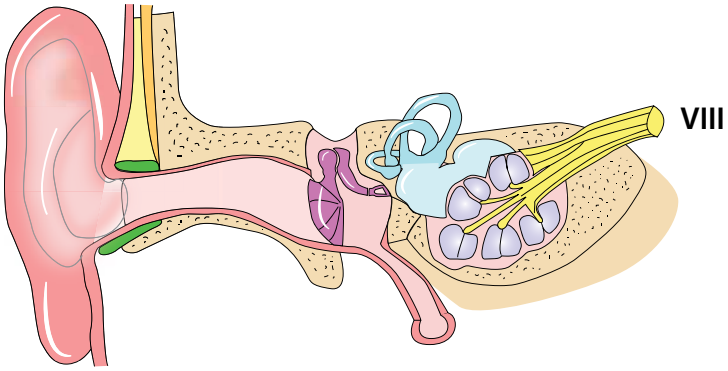
- Lateral pterygoid

Four other Muscles

- Tensor tympani
- Tensor palati
- Mylohyoid
- Anterior belly of digastric

5.6 Cranial Nerves VIII, IX, X, XI, XII

VESTIBULOCOCHLEAR NERVE - VIII



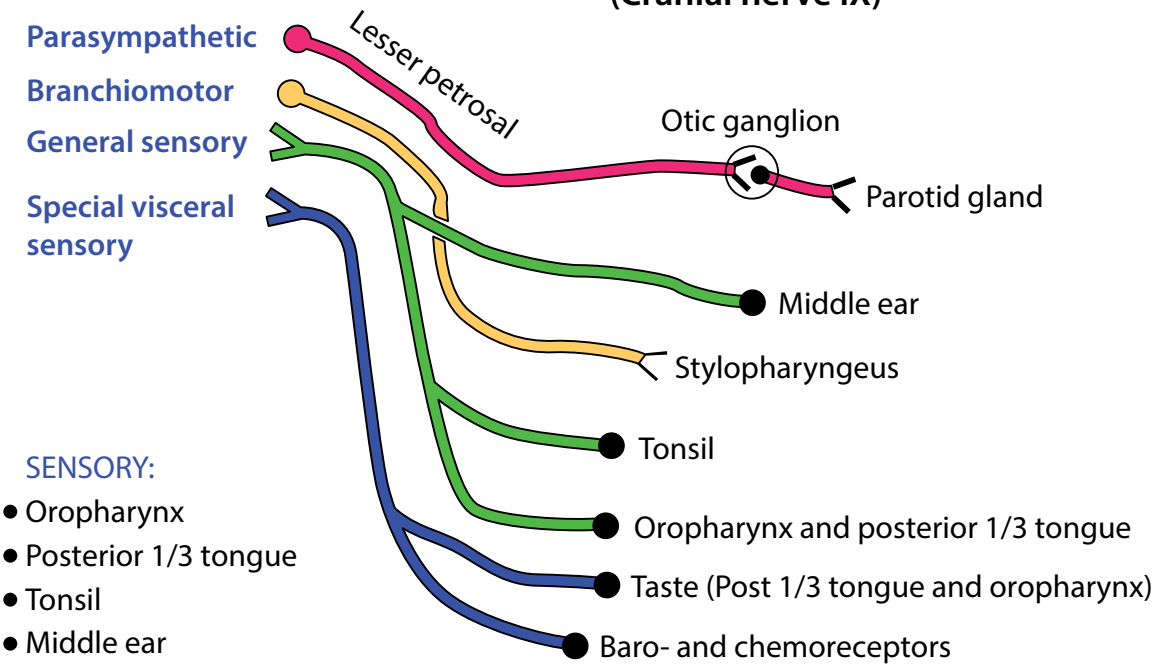
SPECIAL SENSE FOR HEARING AND BALANCE

HEARING: From organ of Corti in cochlea. Hair cells to cell bodies in spiral ganglion (in modiolus). To 2 cochlear nuclei - ventral and dorsal

BALANCE: From semicircular canals, utricle and saccule.

Cell bodies in vestibular ganglion in outer part of internal acoustic meatus. To vestibular nuclei - medial, lateral, superior and inferior

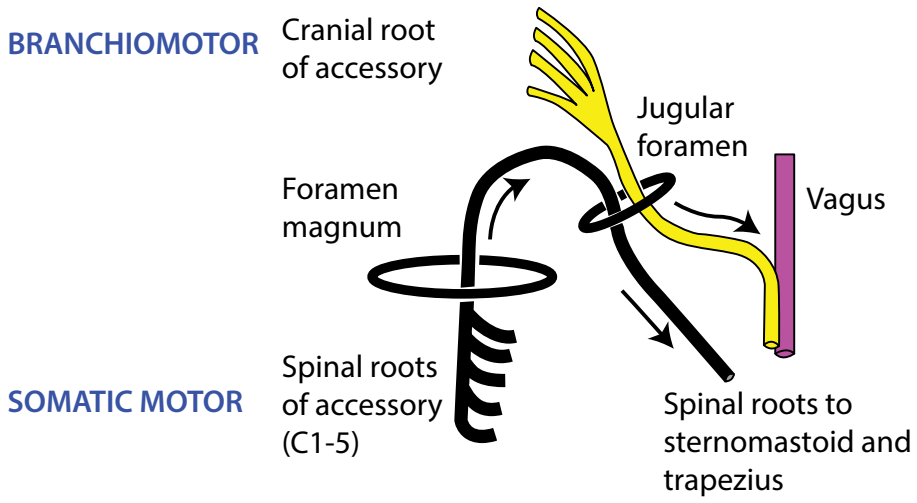
GLOSSOPHARYNGEAL NERVE (Cranial nerve IX)



SENSORY:

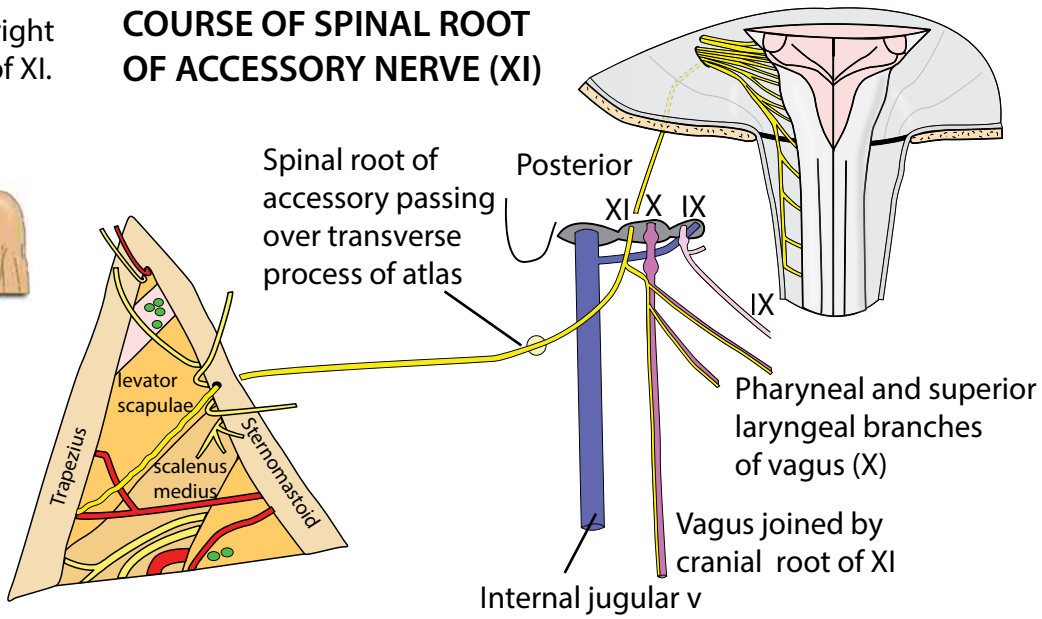
- Oropharynx
- Posterior 1/3 tongue
- Tonsil
- Middle ear

ACCESSORY NERVE
(Cranial nerve XI - accessory to vagus)



Paralysis of right spinal root of XI. Note scar

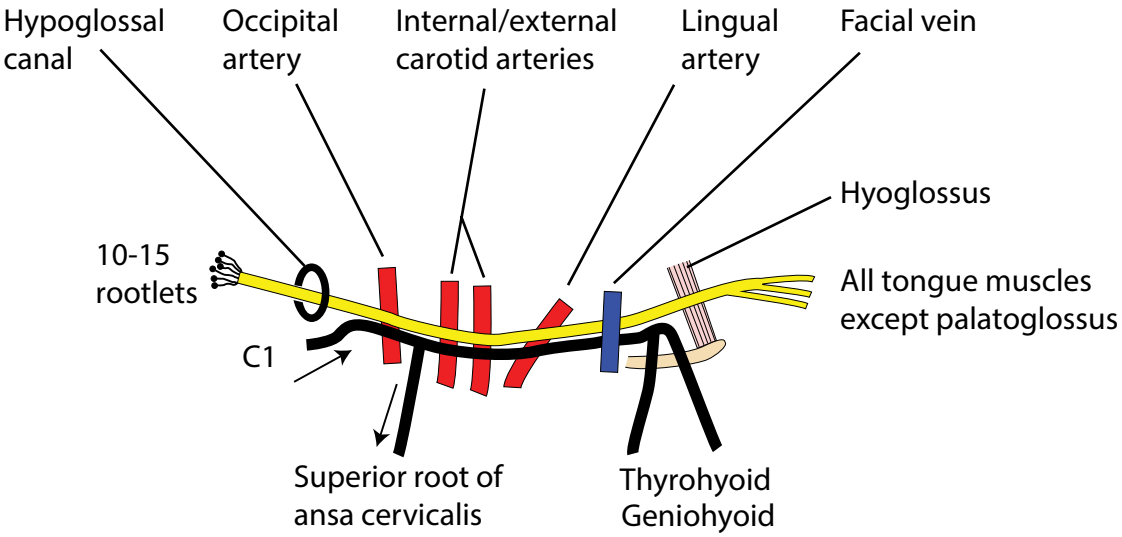
COURSE OF SPINAL ROOT OF ACCESSORY NERVE (XI)



The spinal root of the accessory nerve arises as 5 rootlets from the lateral aspect of the ventral grey horn of C1-5 sections of the spinal cord. The rootlets combine to pass as a single nerve up through the foramen magnum. It then runs out through the jugular foramen with the cranial root. The cranial root joins the vagus and the spinal root passes

HYPOGLOSSAL NERVE (Cranial nerve XII)

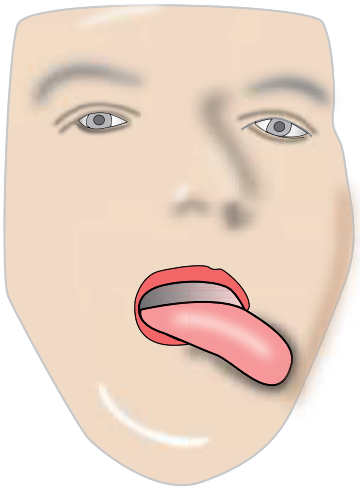
SOMATIC MOTOR



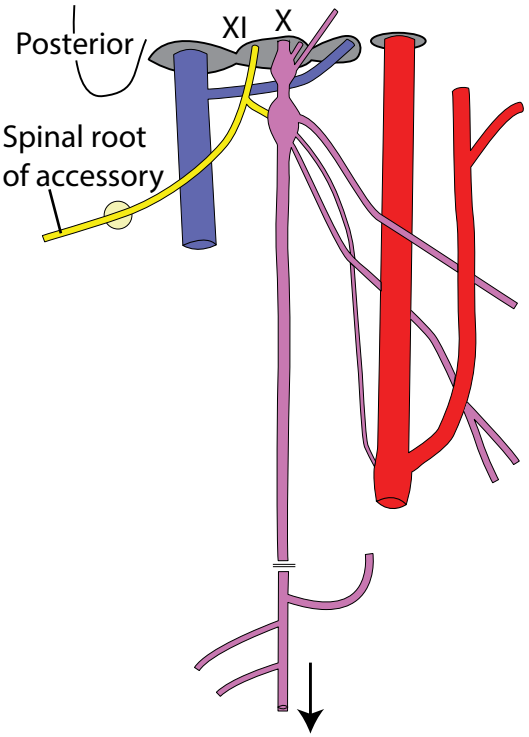
HYPOGLOSSAL NERVE LESIONS

LOWER MOTOR LESION
Tongue protrudes towards side of the nerve lesion

UPPER MOTOR LESION
Tongue protrudes away from the side of the cerebral lesion



VAGUS EXITING RIGHT JUGULAR FORAMEN 1



Vagus arises from 8-10 rootlets on medulla.
Associated nuclei are:

1. Dorsal nucleus of vagus

General visceral efferent: parasympathetic to smooth muscle of bronchi, heart, oesophagus, intestine to transverse colon.

General visceral afferent (sensory) from above organs.

2. Nucleus ambiguus

Branchiomotor supply to striated muscle of palate, pharynx, larynx and upper oesophagus (these fibres originate from the cranial root of accessory).

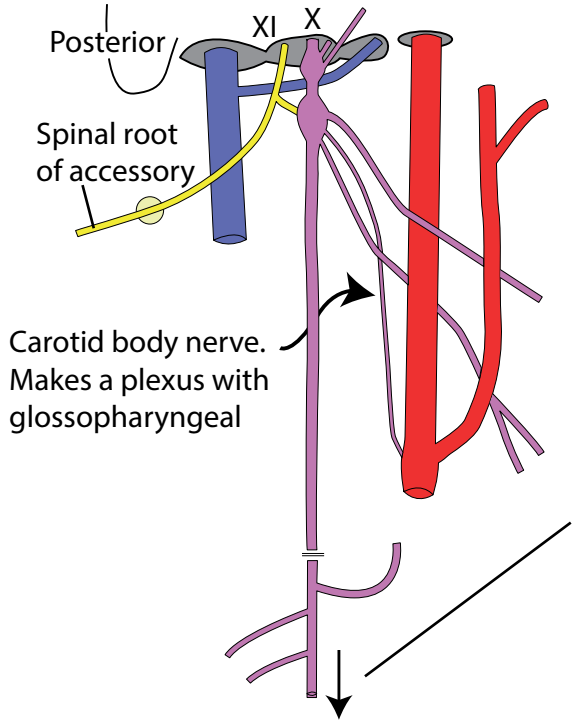
3. Nucleus solitarius

Sensory for baroreceptors and taste.

4. Spinal nucleus of trigeminal nerve

All **somatic sensory** fibres in vagus end here.

VAGUS EXITING RIGHT JUGULAR FORAMEN 2



Superior vagal ganglion - cell bodies for:

1. **Meningeal branch.** Sensory to posterior cranial fossa
2. **Auricular branch.** Sensory to external auditory meatus and part of eardrum (communicates with VII)

Inferior vagal ganglion - cell bodies for:

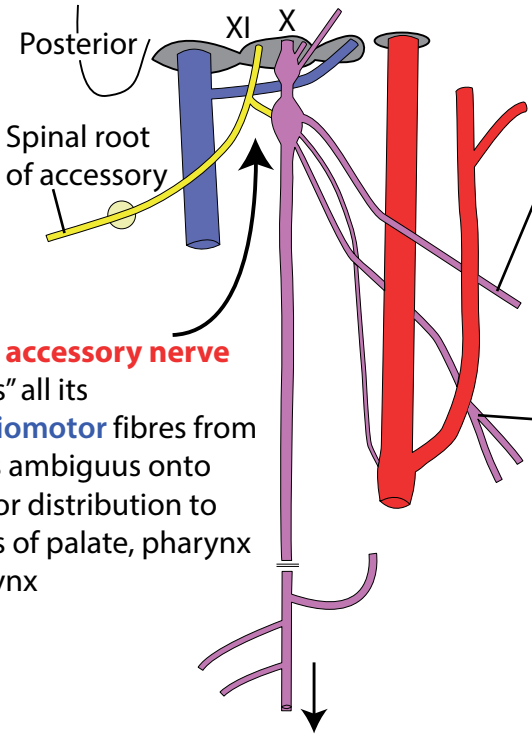
1. **Special visceral afferent** (baroreceptors and taste)
2. **General visceral afferent** (detects stretch and inflammation in heart, lungs, abdominal contents , pharynx and larynx

Vagus continuing

Parasympathetic to pulmonary and oesophageal branches and to coeliac, hepatic and renal plexuses.

Carries **general visceral afferents** from all these organs

VAGUS EXITING RIGHT JUGULAR FORAMEN 3



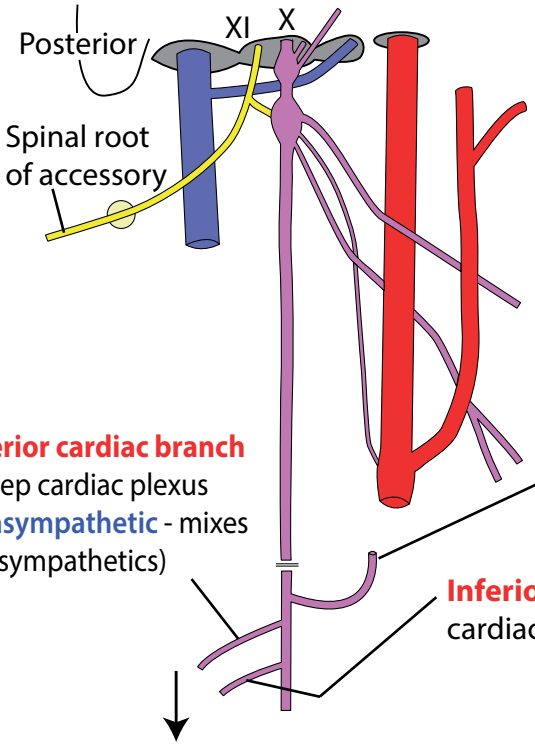
Pharyngeal branch of vagus
Branchiomotor to pharyngeal plexus for muscles of pharynx and palate (excluding tensor palati).

Note that these branchiomotor fibres arise in the nucleus ambiguus and travel in the cranial root of the accessory to reach the vagus (see large arrow)

Cranial accessory nerve
"Dumps" all its **branchiomotor** fibres from nucleus ambiguus onto vagus for distribution to muscles of palate, pharynx and larynx

Superior laryngeal nerve
1. Internal branch: **Somatic sensory** above cords. Small amount of **taste** in valleculae
2. External branch: **Branchiomotor** to cricothyroid

VAGUS EXITING RIGHT JUGULAR FORAMEN 4

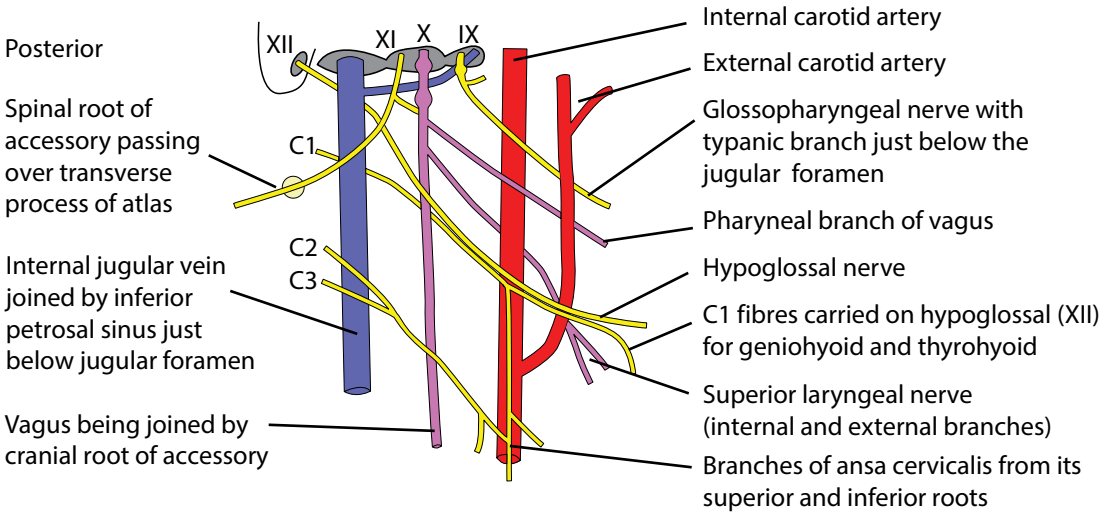


Recurrent laryngeal nerve
1. **Branchiomotor** to muscles of larynx and upper oesophagus
2. **Somatic sensory** to larynx below cords
3. **General visceral afferents** from larynx and pharynx for stretch and inflammation

Superior cardiac branch
to deep cardiac plexus (**parasympathetic** - mixes with sympathetics)

Inferior cardiac branch to deep and superficial cardiac plexuses (**parasympathetic**)

SUMMARY OF RELATIONSHIPS AT RIGHT JUGULAR FORAMEN

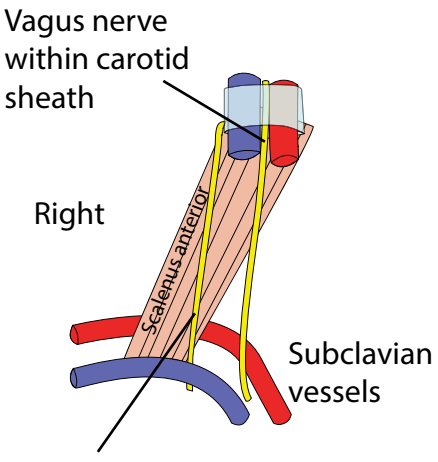


Note:

1. Hyoglossal nerve passes lateral to internal and external carotid arteries
2. Superior laryngeal nerve passes medial to both arteries
3. Glossopharyngeal and pharyneal branch of vagus pass between them

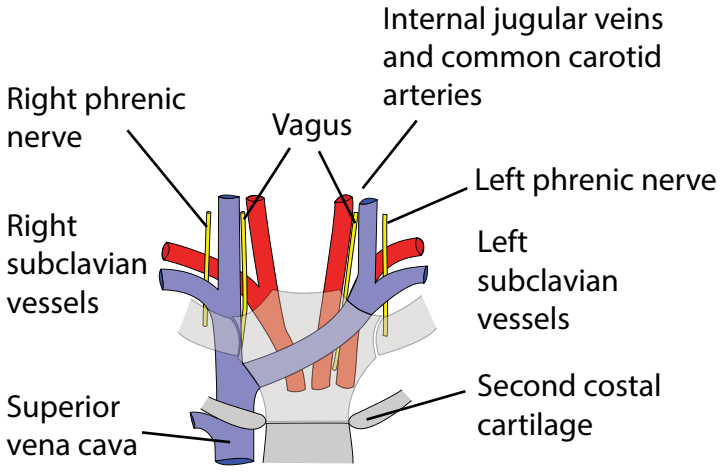
RELATIONSHIPS OF VAGUS AND PHRENIC NERVES

IN NECK



Phrenic nerve emerges from posterior to scalenus anterior to lie on its anterior surface, then off medial edge inferiorly

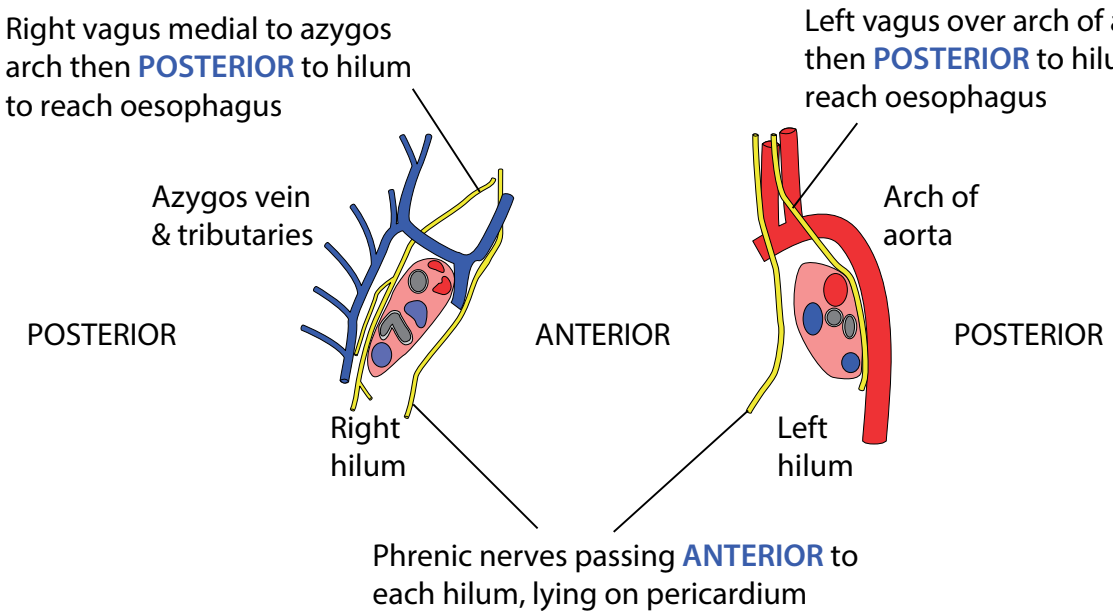
ENTERING THE THORAX



At the level of the thoracic inlet, both vagus and phrenic nerves enter the thorax between the veins anteriorly and the arteries posteriorly

RELATIONSHIPS OF VAGUS AND PHRENIC NERVES

PASSING HILA OF LUNGS



5.7 Rules and Nerve Supply of Muscles

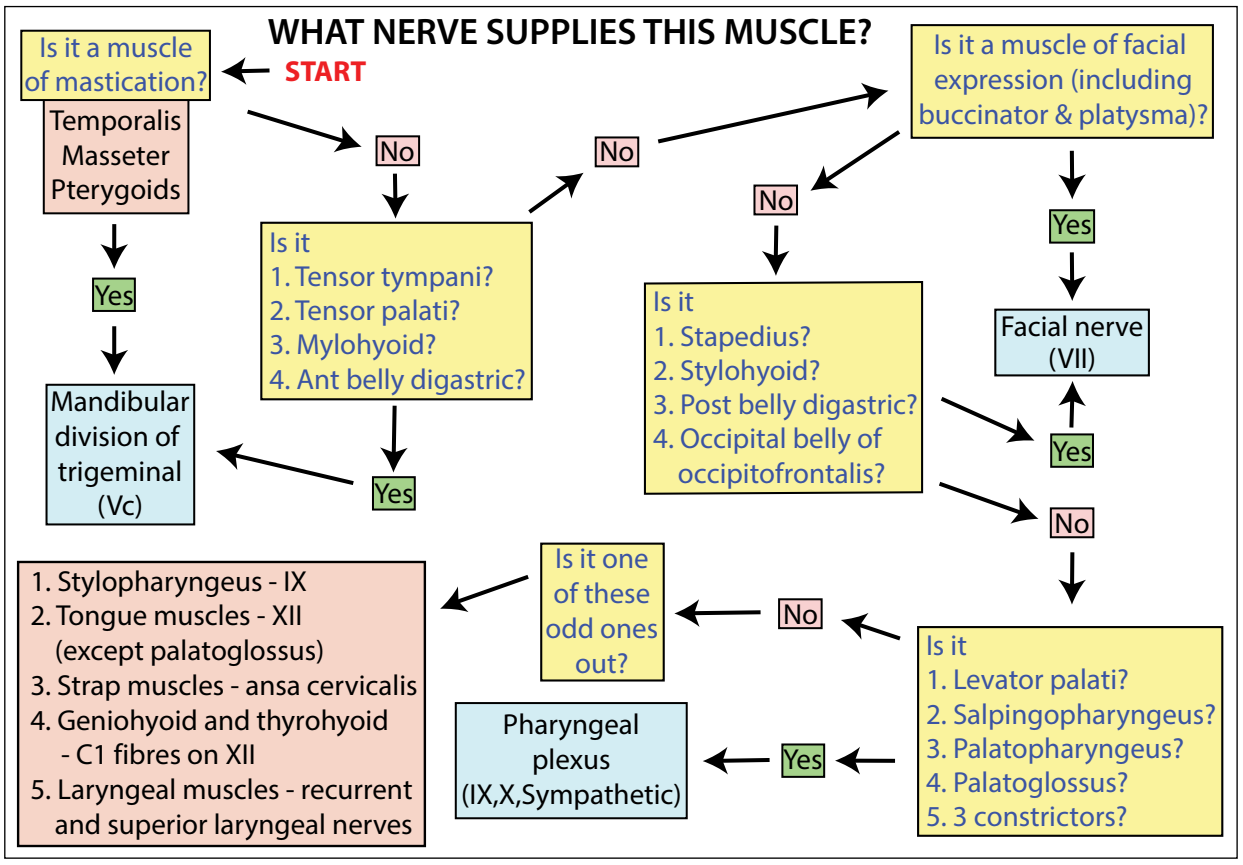
All Muscles of:	Are supplied by:	Except:	Which is/are supplied instead by:
Pharynx	Pharyngeal plexus (IX, X, sympathetic)	Stylopharyngeus	Glossopharyngeal (IX)
		Cricopharyngeus	Recurrent laryngeal
Palate	Pharyngeal plexus (IX, X, sympathetic)	Tensor palati	Off nerve to medial pterygoid (Vc)
Tongue	Hypoglossal (XII)	Palatoglossus	Pharyngeal plexus
Mastication	Mandibular (Vc)	Buccinator	Facial (VII)
Larynx	Recurrent laryngeal (X)	Cricothyroid	External branch of superior laryngeal (X)
Facial expression and buccinator	Facial (VII)	Levator palpebrae superioris	Oculomotor (III) and sympathetic
Eye	Oculomotor (III)	Superior oblique	Trochlear (IV)
		Lateral rectus	Abducent (VI)
Strap group	Ansa cervicalis	Thyrohyoid	C1 fibres on hypoglossal

Muscles: all	**Except**
Strap muscles are supplied by ansa cervicalis	Thyrohyoid which is supplied by C_1 fibres carried on hypoglossal nerve
Muscles of mastication close jaw	Lateral pterygoid which opens it
Muscles of mastication are supplied by mandibular division of trigeminal nerve	Buccinator which is supplied by facial nerve
Muscles of facial expression (including buccinator) are supplied by facial nerve	Levator palpebrae superioris which is supplied by oculomotor (III) nerve and sympathetics
Veins: all	**Except**
Veins draining the thyroid gland enter internal jugular vein	Inferior thyroid veins enter left brachiocephalic vein
Palate: all	**Except**
Muscles of palate and pharynx originate outside pharynx	Levator palati which arises from petrous temporal bone within pharyngobasilar fascia
Muscles of palate are supplied by pharyngeal plexus (IX, X, sympathetic)	Tensor palati which is supplied by mandibular division of trigeminal nerve by a nerve branching off nerve to medial pterygoid (Vc)
Eye: all	**Except**
Nerves to muscles of eye pass through tendinous ring	Trochlear (IV) which passes above it
Extrinsic muscles of eye are supplied by oculomotor nerve (III)	Superior oblique which is supplied by trochlear nerve and lateral rectus which is supplied by abducent nerve (VI)
Extrinsic muscles of eye which are supplied by oculomotor nerve turn eye upwards or inwards	Inferior rectus which turns it downwards and inwards

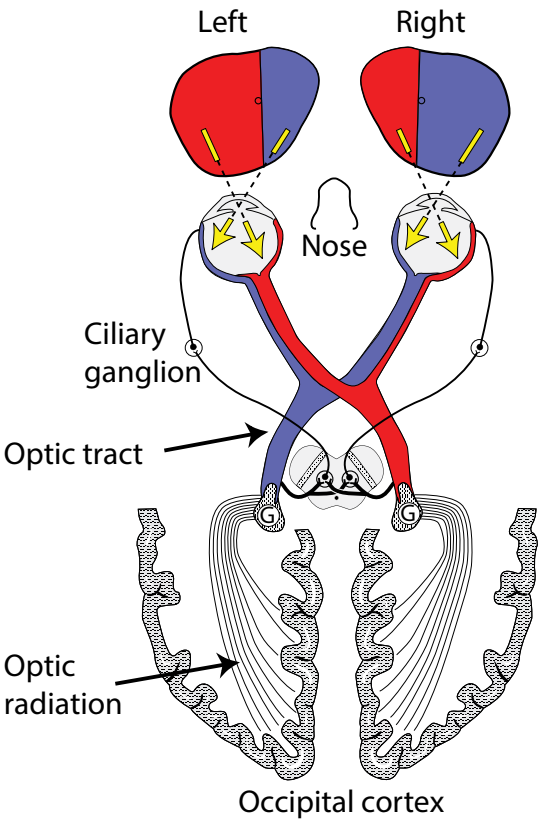
Larynx: all	**Except**
Intrinsic muscles of larynx lie inside larynx	Cricothyroid which lies on outside of larynx
Intrinsic muscles of larynx close, shorten or tighten cords	Posterior crico-arytenoid which opens them
Intrinsic muscles of larynx open, close or loosen cords	Cricothyroid which tightens them
Muscles of larynx are supplied by recurrent laryngeal nerve	Cricothyroid which is supplied by external branch of superior laryngeal branch of vagus
Pharynx: all	**Except**
Muscles of pharynx are relaxed until a bolus arrives	Cricopharyngeus which is tonicallly closed but opens as a bolus approaches
Muscles of pharynx are supplied by pharyngeal plexus (IX, X, sympathetic)	Stylopharyngeus which is supplied by glossopharyngeal nerve and cricopharyngeus which is supplied by the recurrent laryngeal nerve
Sinuses: all	**Except**
Ethmoid sinuses open into middle meatus of nose	Posterior ethmoidal which opens into superior meatus
Paranasal air sinuses are present at birth	Frontal which appears at approximately age of 2 years
Skull foramina: all	**Except**
Important foramina leaving or entering base of skull from inside, lie on an oval which passes through foramen magnum and lesser wings of sphenoid	Cribriform plate of ethmoid, foramen lacerum and foramen caecum which do not lie on this oval
Pharyngeal arches: all	**Except**
Branchial arches give rise to several muscles	Third arch which has a single muscle - stylopharyngeus

Cranial nerves: all	Except
Cranial nerves have bilateral control from cortex	Facial nerve to lower face
Cranial nerves leave brain stem (midbrain, pons and medulla)	Olfactory (I) and Optic (II) which are extended brain tissue emerging further anteriorly
Branches of trigeminal nerve (V) enter cavernous sinus	Mandibular division
Cell bodies for taste lie in geniculate ganglion	Glossopharyngeal (IX) and vagus (X) which each have a sensory ganglion just below jugular foramen
Sensory fibres in trigeminal nerve (V) have their cell bodies (nuclei) in trigeminal ganglion	Proprioception which has its cell bodies in mesencephalic part of trigeminal nucleus in brain stem
Fibres in trigeminal nerve (V) pass through trigeminal ganglion	Motor fibres in its mandibular branch
Three main branches of trigeminal nerve (V) have three branches to skin	Ophthalmic branch which has five skin branches
Muscles of tongue are supplied by hypoglossal nerve (XII)	Palatoglossus which is supplied by pharyngeal plexus
Of the hypoglossal nerve (XII) passes lateral to all important structures in neck	Facial vein which passes lateral to the nerve

Autonomics: all	**Except**
Four parasympathetic ganglia in head supply salivary or mucous glands	Ciliary ganglion in the orbit which supplies eye with accommodation and pupillary constriction only
Postganglionic parasympathetic fibres are carried from their ganglion to their destination by branches of trigeminal nerve (V) which join at a parasympathetic ganglion	In the case of submandibular ganglion preganglionic parasympathetic fibres (in chorda tympani) are also carried TO ganglion by a branch of V (lingual nerve)
Sympathetic preganglionic fibres synapse before leaving sympathetic chain	Unless they are destined to supply abdominal contents or, specifically, the adrenal gland
Sympathetic fibres that pass through four parasympathetic ganglion in head are carried by internal carotid artery or its branches	Sympathetic fibres in submandibular and otic ganglia leave facial and middle meningeal arteries respectively
Other nerves: all	**Except**
Sensory cell bodies for sensory nerves lie outside the central nervous system	Proprioception for head which has its cell bodies in mesencephalic part of trigeminal nucleus in brain stem
Posterior rami of somatic nerves reach and supply skin	C1, L1, S1 do not reach skin
Nerves leave their intervertebral foramina below same named vertebral body	Upper 7 cervical nerves which exit above their same named bodies. C8 exits below C7 vertebra
Somatic cervical nerves emerge posterolateral to vertebral artery	Anterior ramus of C1 nerve which passes vertebral artery anteromedially


WHAT NERVE SUPPLIES THIS MUSCLE?
START
Is it a muscle of mastication?
Temporalis
Masseter
Pterygoids
Yes
Mandibular division of trigeminal (Vc)
No
Is it
1. Tensor tympani?
2. Tensor palati?
3. Mylohyoid?
4. Ant belly digastric?
Yes
No
Is it a muscle of facial expression (including buccinator & platysma)?
Yes
Facial nerve (VII)
No
Is it
1. Stapedius?
2. Stylohyoid?
3. Post belly digastric?
4. Occipital belly of occipitofrontalis?
Yes
No
Is it
1. Levator palati?
2. Salpingopharyngeus?
3. Palatopharyngeus?
4. Palatoglossus?
5. 3 constrictors?
Yes
Pharyngeal plexus (IX,X,Sympathetic)
No
Is it one of these odd ones out?
1. Stylopharyngeus - IX
2. Tongue muscles - XII (except palatoglossus)
3. Strap muscles - ansa cervicalis
4. Geniohyoid and thyrohyoid - C1 fibres on XII
5. Laryngeal muscles - recurrent and superior laryngeal nerves

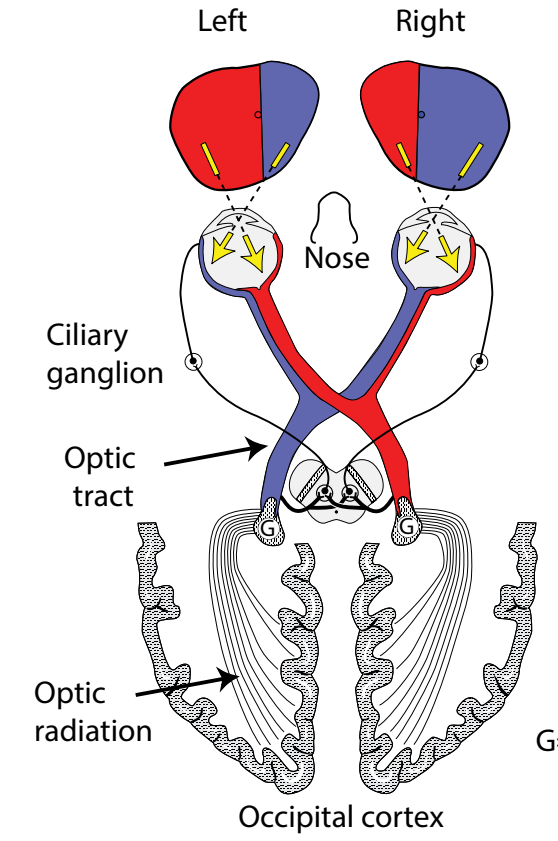
5.8 Eye Visual Pathways, CN III, IV, VI, Autonomics and Oculomotor Versus Horner's



OPTIC NERVE - II

From the lateral geniculate bodies fibres pass in the optic radiations to the left and right occipital cortex where the images arrive inverted (upside down). To initiate rapid reflexes at brain stem level, the incoming fibres from the eye must connect to the mid brain which lies near the optic tracts. These fibres from each optic tracts synapse with both Edinger Westphal nuclei so that all reflexes are bilateral. Parasympathetics from the Edinger Westphal nuclei synapse in the ciliary ganglia and then supply the sphincter pupillae muscles for constricting the pupils in the light reflex.

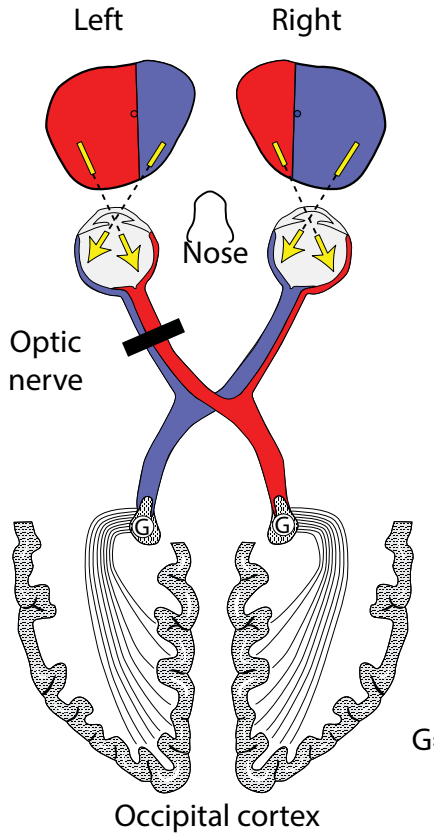
G= Lateral geniculate body



NORMAL VISUAL PATHWAYS

Light is detected on the retina and transmitted in the optic nerves to the chiasma where the fibres from the lateral field (medial retina) cross. The cell bodies are in the lateral geniculate body. Fibres continue to the occipital cortex via the optic radiations.
A small amount of the optic fibres enter the pretectal nuclei in the mid brain which are connected to the oculomotor and Edinger Westphal nuclei bilaterally to enable the consensual light reflex.

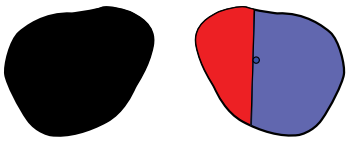
G= Lateral geniculate body



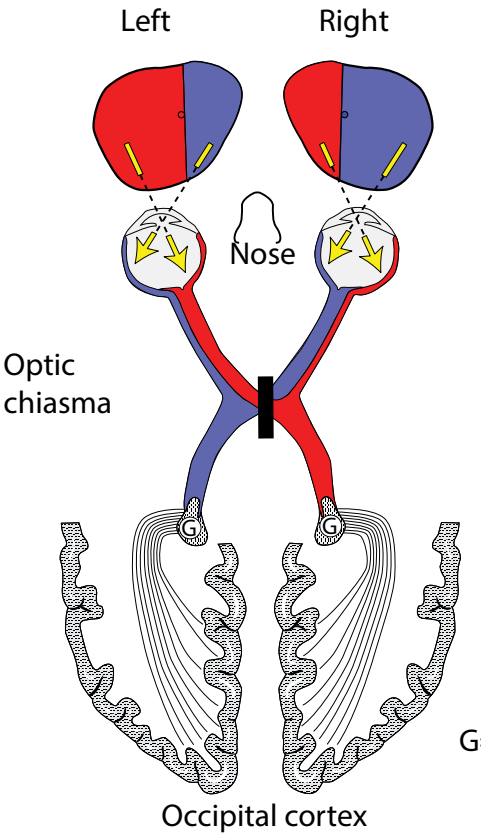
VISUAL DEFECTS 1

LESION 1: DAMAGE TO OPTIC NERVE
Complete destruction of the left optic nerve gives blindness in the left eye

BLINDNESS



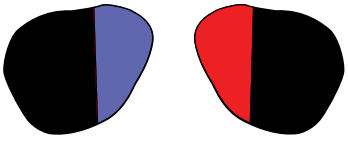
G= Lateral geniculate body



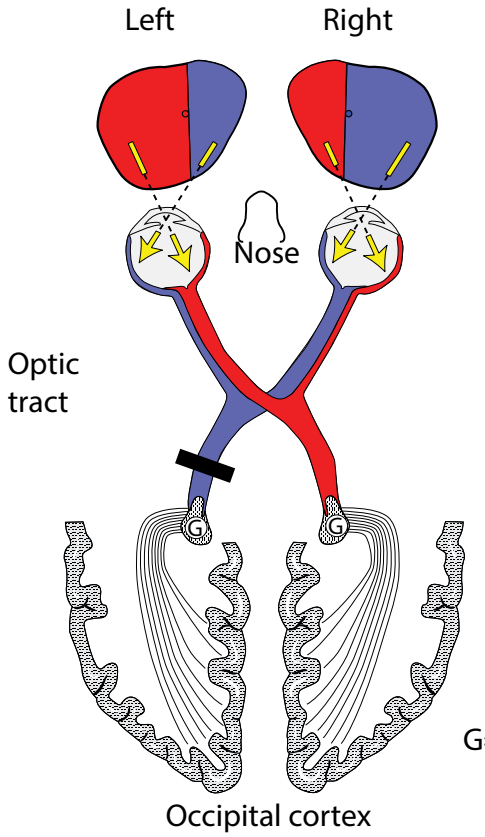
VISUAL DEFECTS 2

LESION 2: DAMAGE TO OPTIC CHIASMA
Complete destruction of all the crossing fibres leads to blindness of both temporal visual fields.

BITEMPORAL HEMIANOPIA



G= Lateral geniculate body

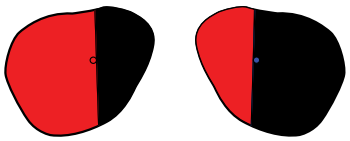


VISUAL DEFECTS 3

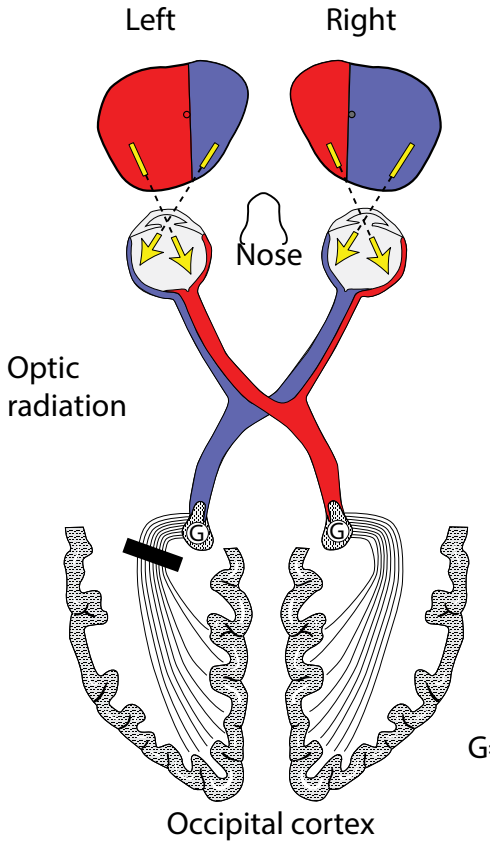
LESION 3: DAMAGE TO OPTIC TRACT

Complete destruction of all fibres in the left optic tract leads to blindness of both right visual fields.

RIGHT HOMONYMOUS HEMIANOPIA



G= Lateral geniculate body

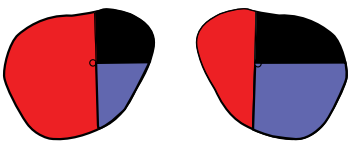


VISUAL DEFECTS 4

LESION 4: DAMAGE TO OPTIC RADIATION

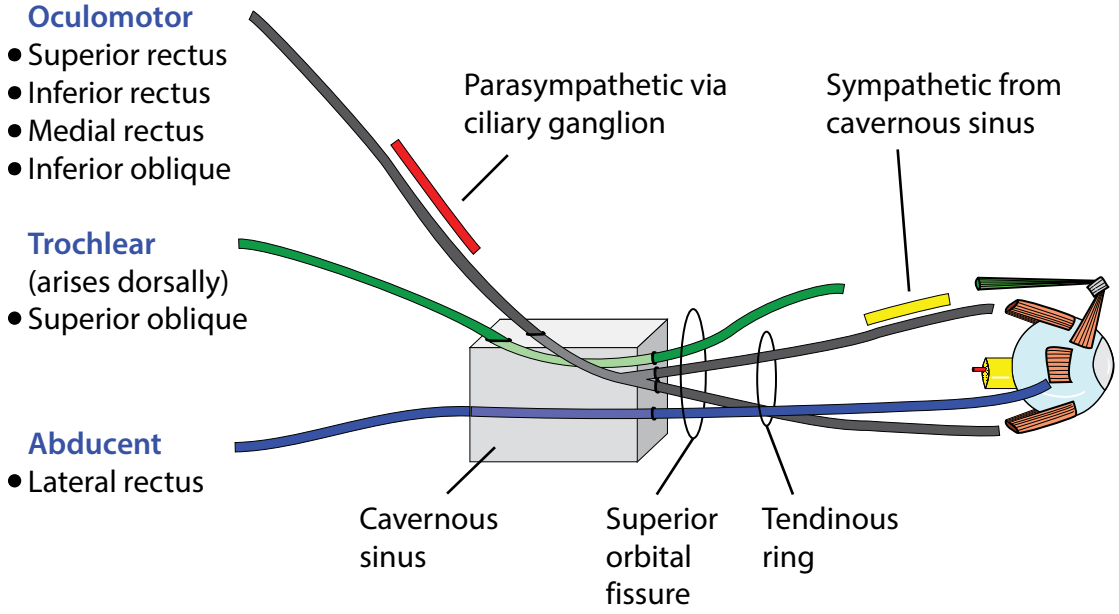
Selective destruction of fibres in the left optic radiation leads to variations on the theme of a RIGHT HOMONYMOUS HEMIANOPIA that may be loss of a quadrant.

QUADRANTIC HOMONYMOUS HEMIANOPIA

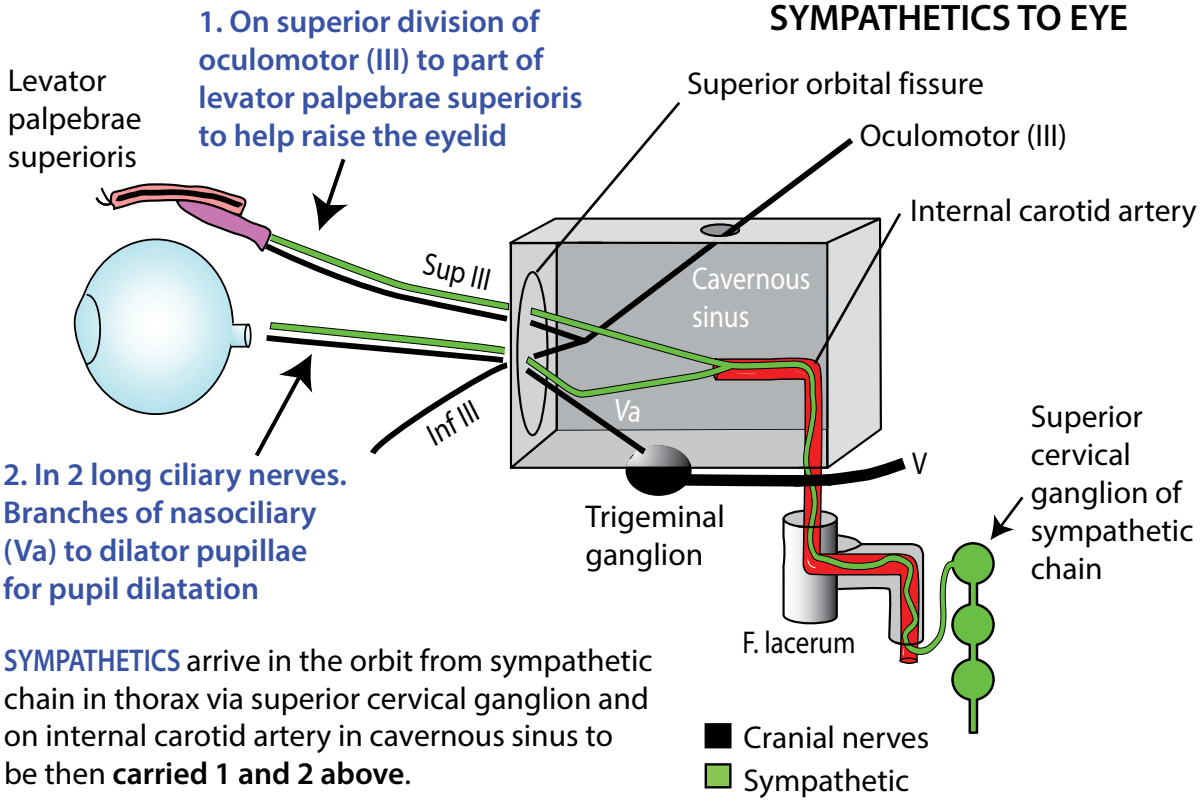


G= Lateral geniculate body

NERVES: OCULOMOTOR - III, TROCHLEAR - IV, ABDUCENT - VI

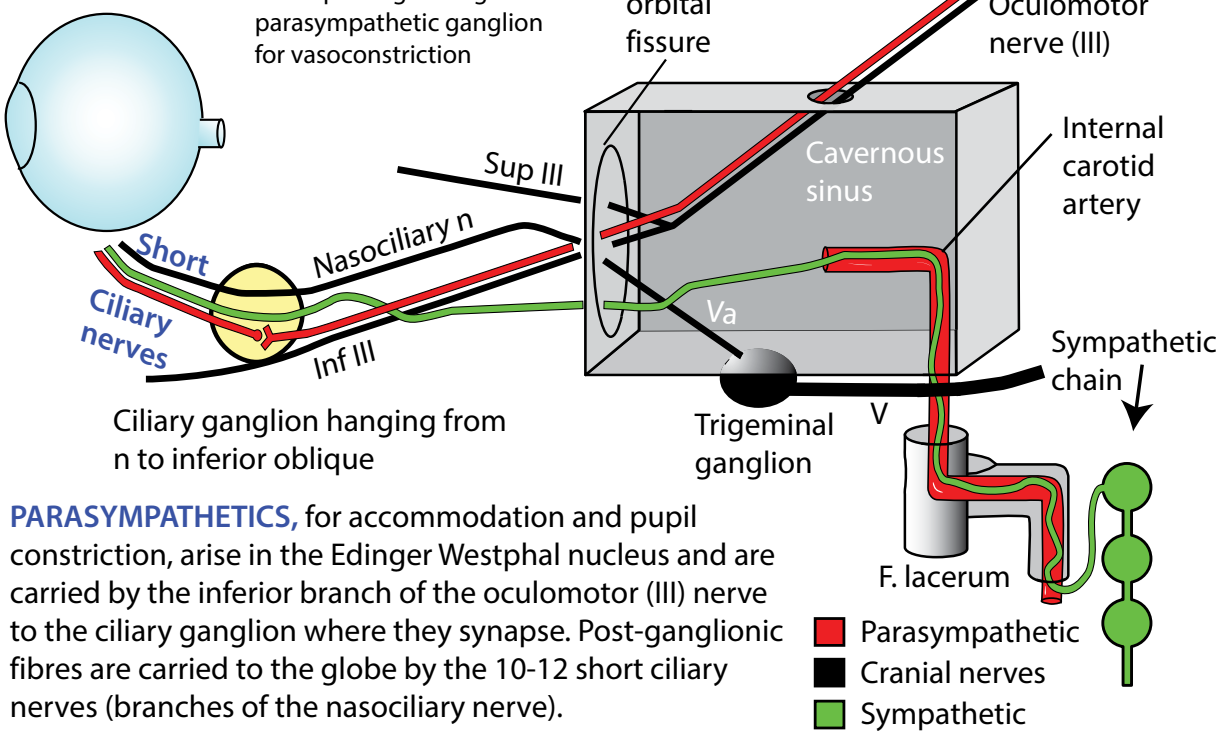


SYMPATHETICS TO EYE



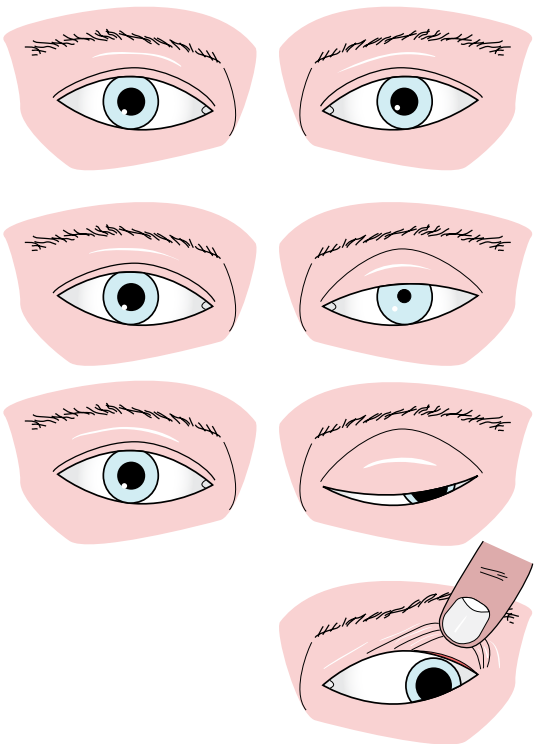
SYMPATHETICS arrive in the orbit from sympathetic chain in thorax via superior cervical ganglion and on internal carotid artery in cavernous sinus to be then **carried 1 and 2 above**.

PARASYMPATHETICS TO EYE



PARASYMPATHETICS, for accommodation and pupil constriction, arise in the Edinger Westphal nucleus and are carried by the inferior branch of the oculomotor (III) nerve to the ciliary ganglion where they synapse. Post-ganglionic fibres are carried to the globe by the 10-12 short ciliary nerves (branches of the nasociliary nerve).

COMPARING HORNER'S SYNDROME WITH OCULOMOTOR LESION



NORMAL

LEFT HORNER'S SYNDROME
- Moderate ptosis
- Small pupil
- No problems with eye movements

LEFT 3rd NERVE PALSY
- Severe ptosis
- Large pupil
- Down and out gaze

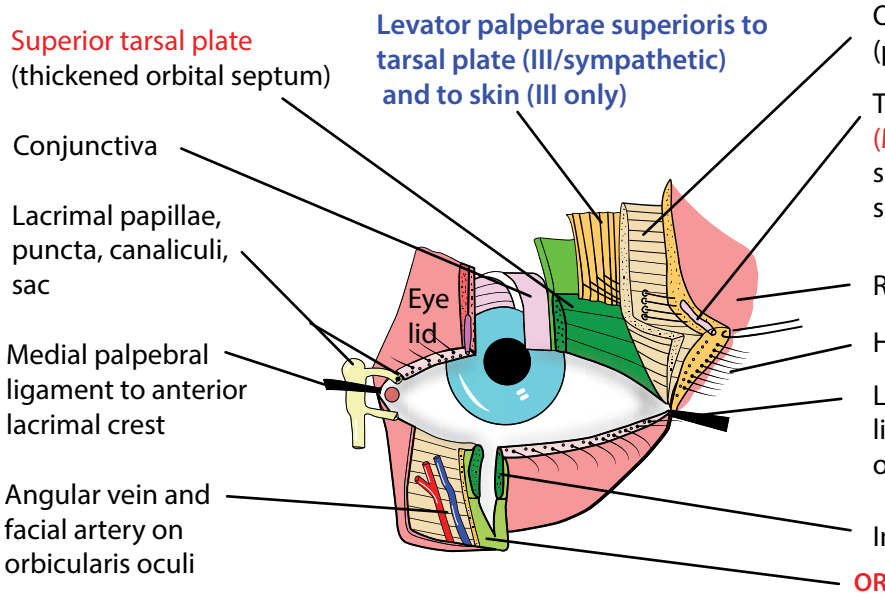
HORNER'S VERSUS OCULOMOTOR (III) NERVE LESION

LESION	PUPIL SIZE	PTOSIS	FACE	EYE MOVEMENTS
HORNER'S (loss of sympathetic)	SMALL	YES (mild)	DRY FLUSHED	NORMAL
Oculomotor (III)	LARGE (loss of parasympathetic)	YES (severe) (loss of somatic)	NORMAL	PATIENT LOOKS DOWNWARDS AND OUTWARDS (sole action of superior oblique and lateral rectus)

NOTE: Levator palpebrae superioris needs both sympathetic and somatic nerves to function correctly

5.9 Eye Lids, Orbit, Lacrimal Gland, Retina and Optic Nerve

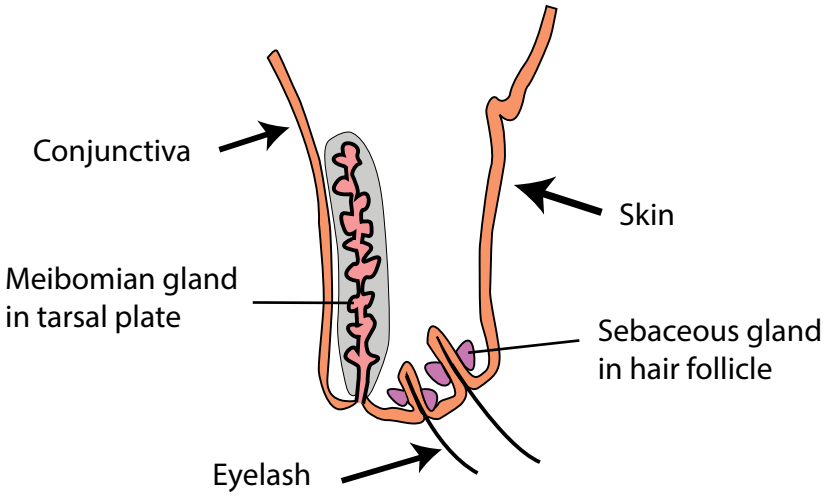
EXPLODED VIEW OF LEFT EYELIDS



Blood supply: Palpebral branches of ophthalmic artery
Nerves: Upper skin/conjunctiva: lacrimal, supra-orbital (Va). Lower skin/conjunctiva: infra-orbital (Vb)

(palpebral ligament/fascia). Fibrous portion of eyelids. Keeps lids stable as eye moves. From LPS above to lower tarsal plate. Separates orbital structures from anterior eyeball. Cellulitis anterior to it, periorbital cellulitis, posterior involving the orbit

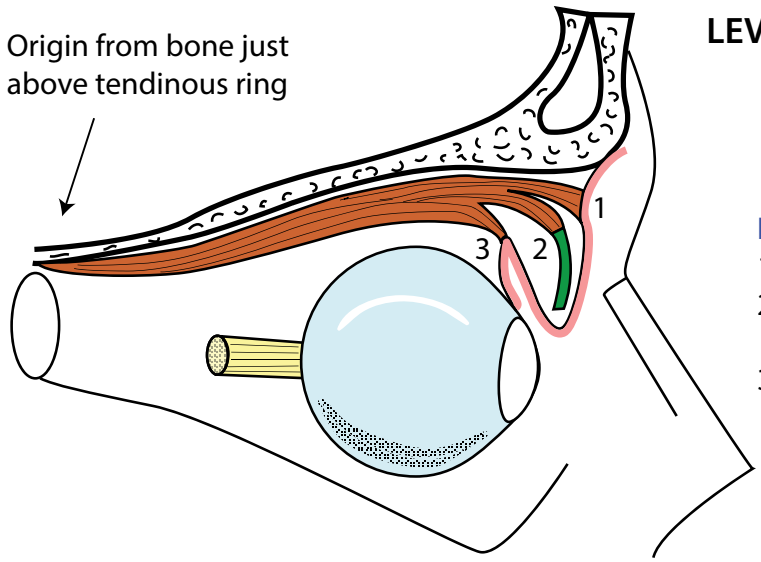
ANATOMY OF STYE AND MEIBOMIAN LESIONS



A **stye** is an infection of the sebaceous gland associated with a hair follicle.

If a **meibomian gland** become infected it becomes a **meibomian abscess**.
If the duct is simply blocked the gland becomes a **cyst (chalazion)**

LEVATOR PALPEBRAE SUPERIORIS

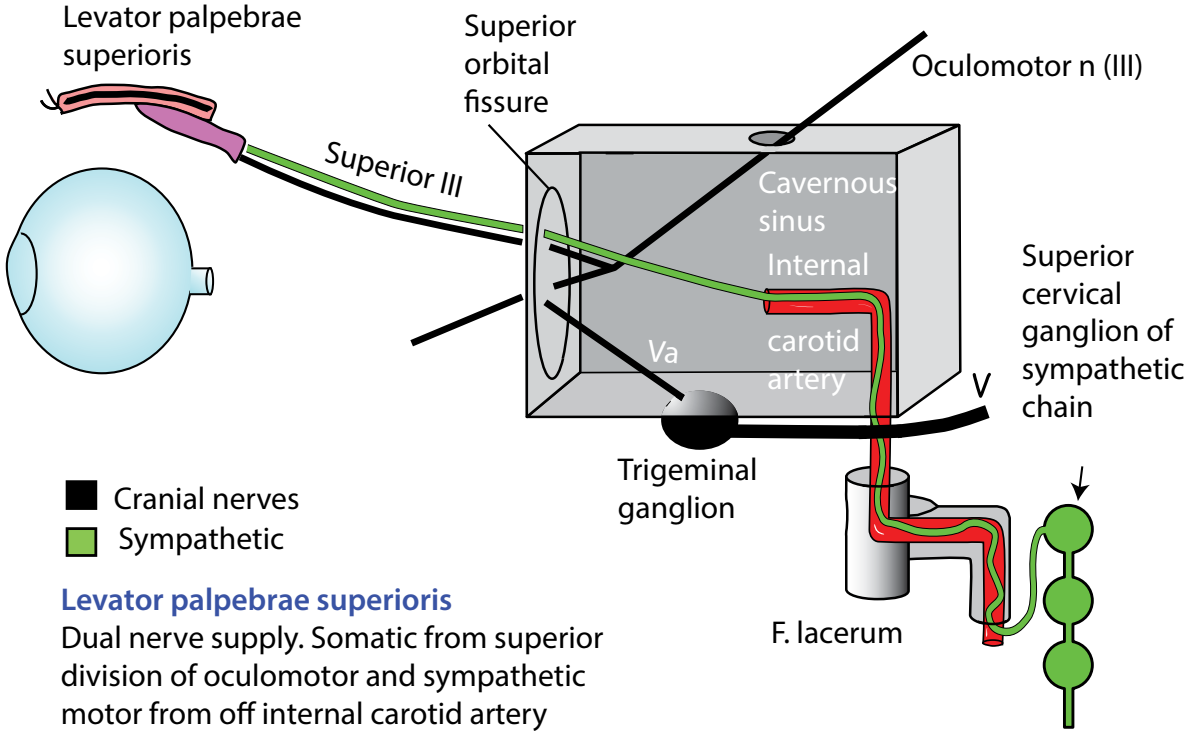


Insertion into:
1. Eyelid skin
2. Tarsal plate and Muller's muscle
3. Conjunctival sac

Nerve supply:
- Oculomotor (III) to all three insertions (somatic) so defect gives complete ptosis.
- Sympathetic to Muller's muscle to tarsal plate only (autonomic) so defect gives only partial ptosis.

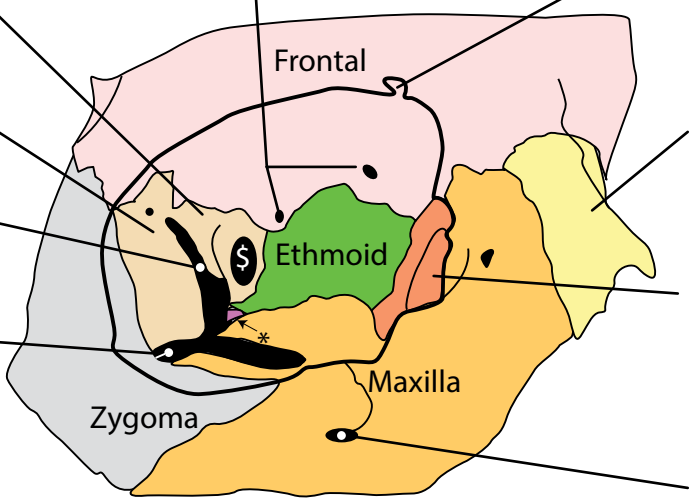
Note: For levator palpebrae superioris to function correctly both somatic and sympathetic supply must be intact

LEVATOR PALPEBRAE SUPERIORIS



Levator palpebrae superioris
Dual nerve supply. Somatic from superior division of oculomotor and sympathetic motor from off internal carotid artery

BONES OF RIGHT ORBIT

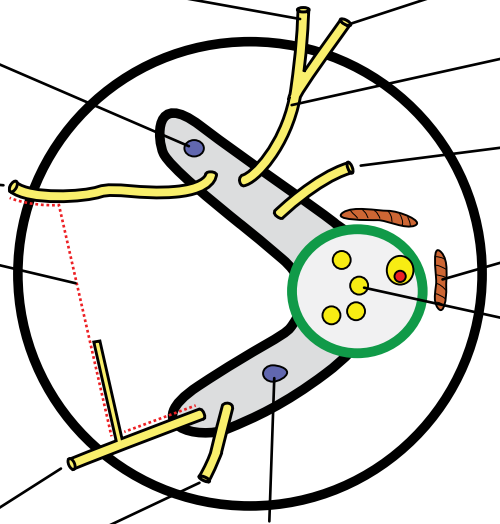


* Orbital process of palatine bone

$= Optic canal

Note: Fracture/depression of zygoma may give diplopia. Aslo, and more commonly, diplopia is seen in fractures of the maxilla and ethmoid

STRUCTURES PASSING THROUGH RIGHT SUPERIOR/INFERIOR ORBITAL FISSURES



Supra-orbital nerve

Supratrochlear nerve

Superior ophthalmic vein

Frontal nerve (Va)

Trochlear nerve (IV)

Lacrimal nerve (Va)

Parasympathetic connection to lacrimal gland on zygomaticotemporal nerve

Superior oblique

Nasociliary nerve (Va) passes out of the cone of muscles to give:

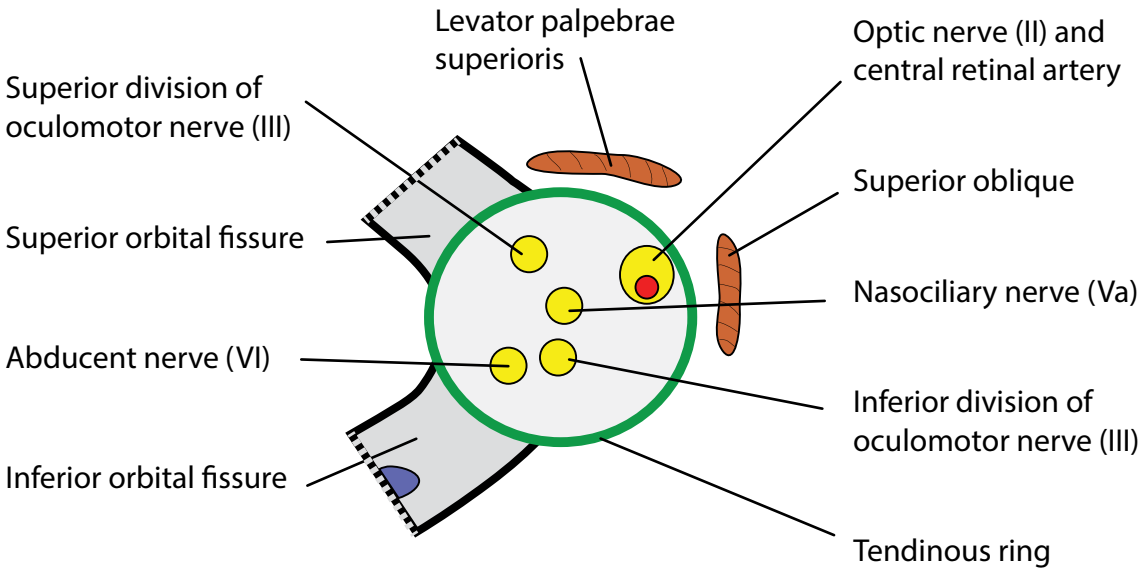
- Posterior ethmoidal
- Anterior ethmoidal
- Infratrochlear
- Long and short ciliary nerves

Zygomatic nerve (Vb)

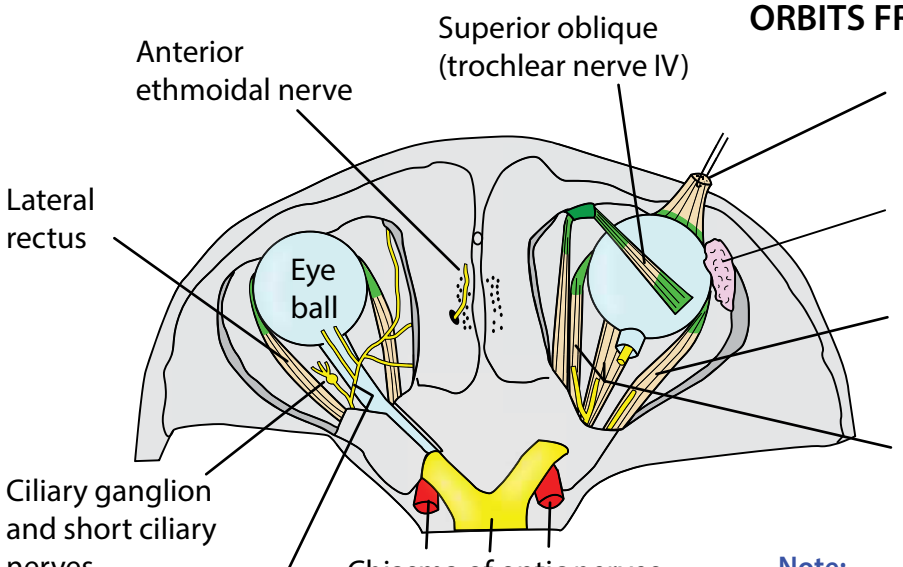
Infra-orbital nerve (Vb)

Inferior ophthalmic vein

STRUCTURES PASSING THROUGH RIGHT TENDINOUS RING



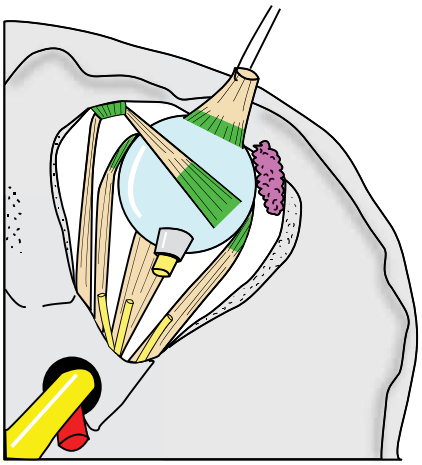
ORBITS FROM ABOVE



Note:

- Medial orbital walls are parallel
- Lateral walls are at right angles
- Orbital fascia is the periostium of orbit which is continuous with dura over optic nerve

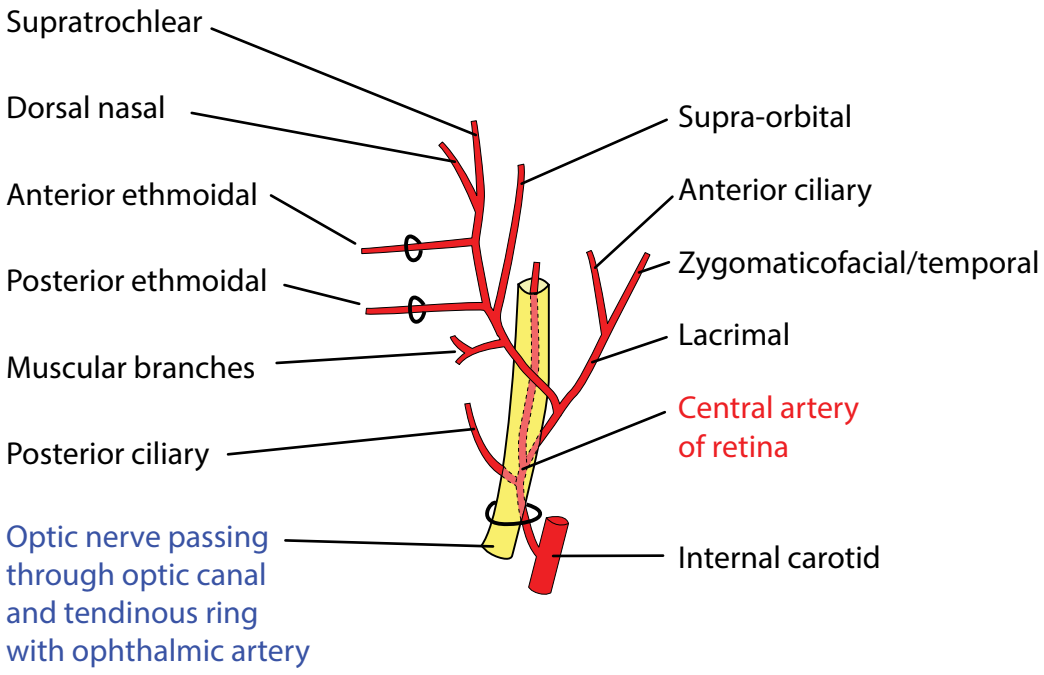
LACRIMAL GLAND



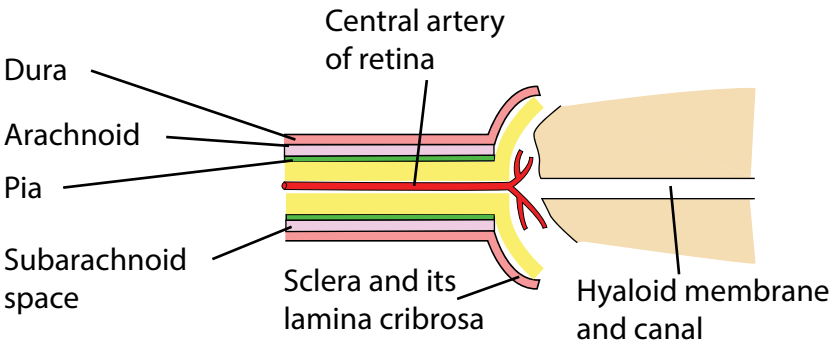
Looking down into right orbit

Serous gland in lateral roof of orbit. 10-12 ducts draining into lateral/superior fornix of conjunctiva. Tears swept medially by progressive lid closure.
Blinking: By palpebral part of obicularis oculi (no tear spill)
Screwing up: By orbital part of obicularis oculi (tears spill and lacrimal sac is squeezed)
Lacrimal sac has palpebral fibres of orbicularis oculi inserting into it to open it and to suck in tears.
Lacrimal lake lies above it. lacrimal duct is 2cm long, drains into inferior meatus of lateral wall of nose and its mucosal folds are valvular to stop air ascending
Nerve supply: Secretomotor. Superior salivary nucleus to facial nerve to greater petrosal nerve to pterygopalatine ganglion to zygomatic branch of maxillary division of trigeminal (Vb) to zygomaticotemporal nerve to connecting branch in orbit to lacrimal nerve (Va) to gland

RIGHT OPHTHALMIC ARTERY (viewed from above)



EYE - OPTIC NERVE AND ITS COVERINGS



OPTIC NERVE: 3cm in orbit

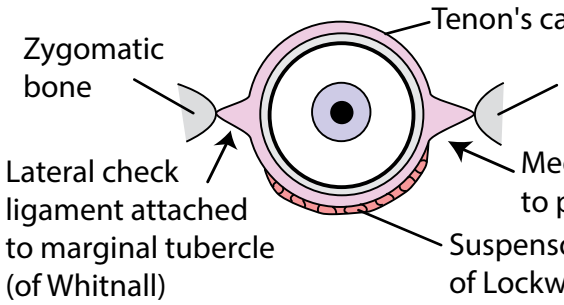
Blood supply:

Intracranial portion - Anterior cerebral artery
Posterior 2cm in orbit - Ophthalmic artery
Anterior 1cm in orbit - Central artery of retina

Papilloedema: Swelling of the optic disc occurs when the pressure of the CSF in the subarachnoid space is raised. The increased pressure partially obstructs the retinal veins which in turn leads to oedema

Right normal fundus

FASCIAL COVERINGS OF EYE



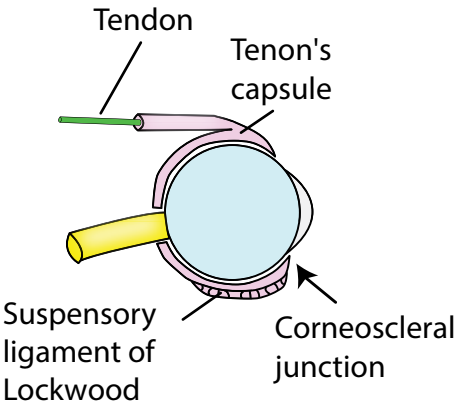
Right eye viewed from front

TENON'S CAPSULE (Fascia bulbi)

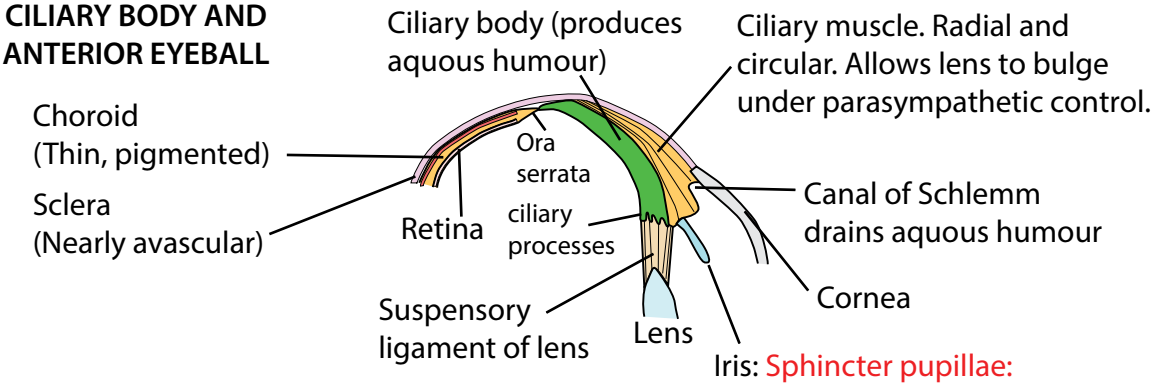
- Fascial sheath of eye
- Bursa behind the eyeball
- Inner layer blends with sclera
- Outer layer pierced by tendons and it extends back along them

Note: There is not normally any posterior displacement of the eyeball because of the following factors:

- Medial and lateral check ligaments
- Presence of orbital fat
- Forward pull of 2 oblique muscles



CILIARY BODY AND ANTERIOR EYEBALL



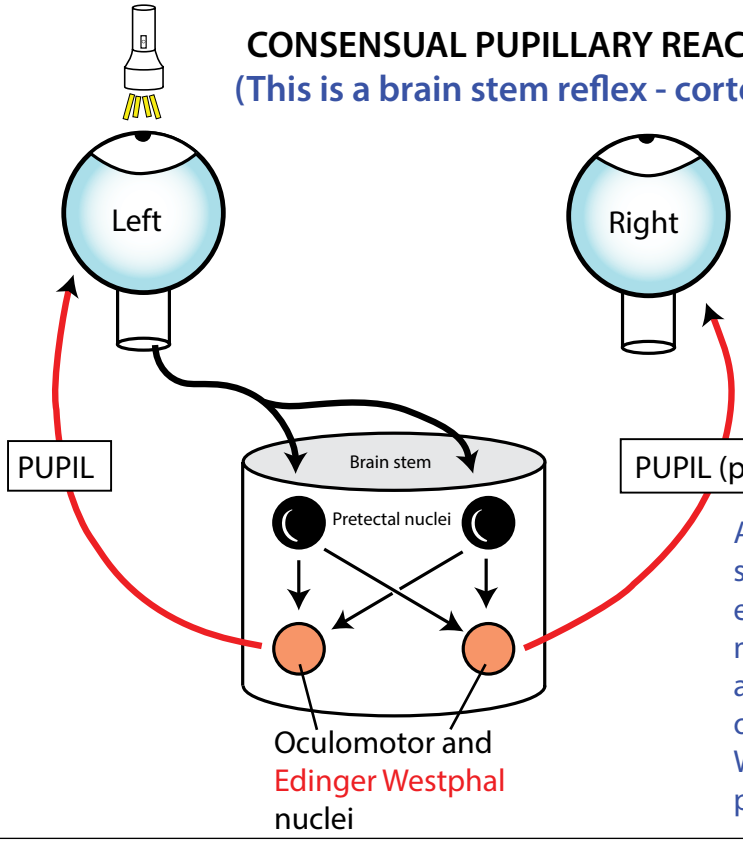
RETINA

- Attached to choroid
- Outside vitreous humour
- Stops at ora serrata
- **Optic disc:** Blind spot at entry of optic nerve (1.5mm)
- **Macula lutea** - 3mm lateral to disc. Has central pit (fovea) with cones only
- **Rods:** For dim light and no colour
- **Cones:** For colour. Very sensitive
- **Fundus:** Entry of optic nerve and vessels. Seen with ophthalmoscope at back of eye
- **Blood supply:** Central artery of retina. Central veins to superior ophthalmic veins

5.10 Eye Light and Near Reactions, Eye Movements and Pupil Control

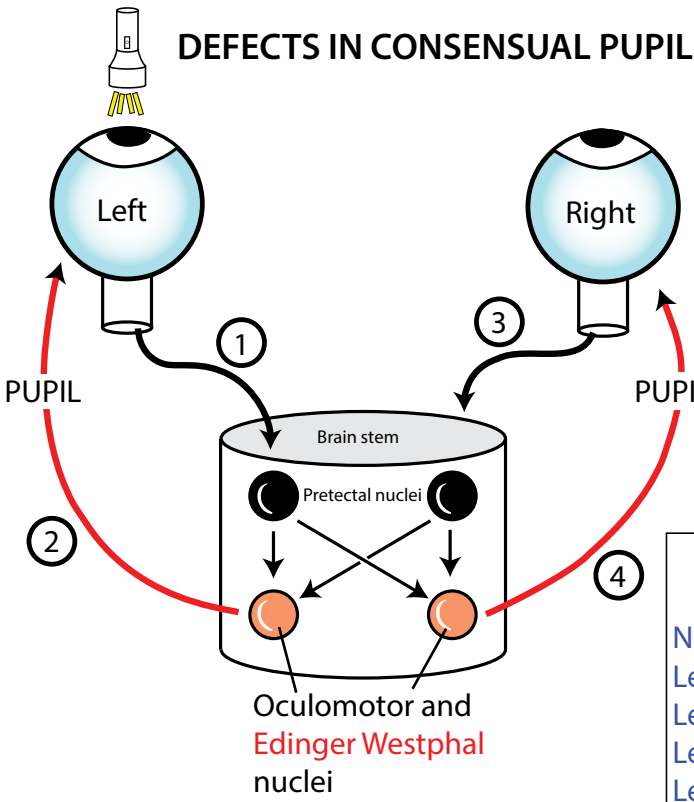
CONSENSUAL PUPILLARY REACTION TO LIGHT

(This is a brain stem reflex - cortex not involved)



A small proportion of the sensation of light from the retina enters the pretectal nuclei in the midbrain bilaterally. These nuclei are connected to both the oculomotor and Edinger Westphal nuclei to conduct the pupillary light reflex.

DEFECTS IN CONSENSUAL PUPILLARY REACTION TO LIGHT

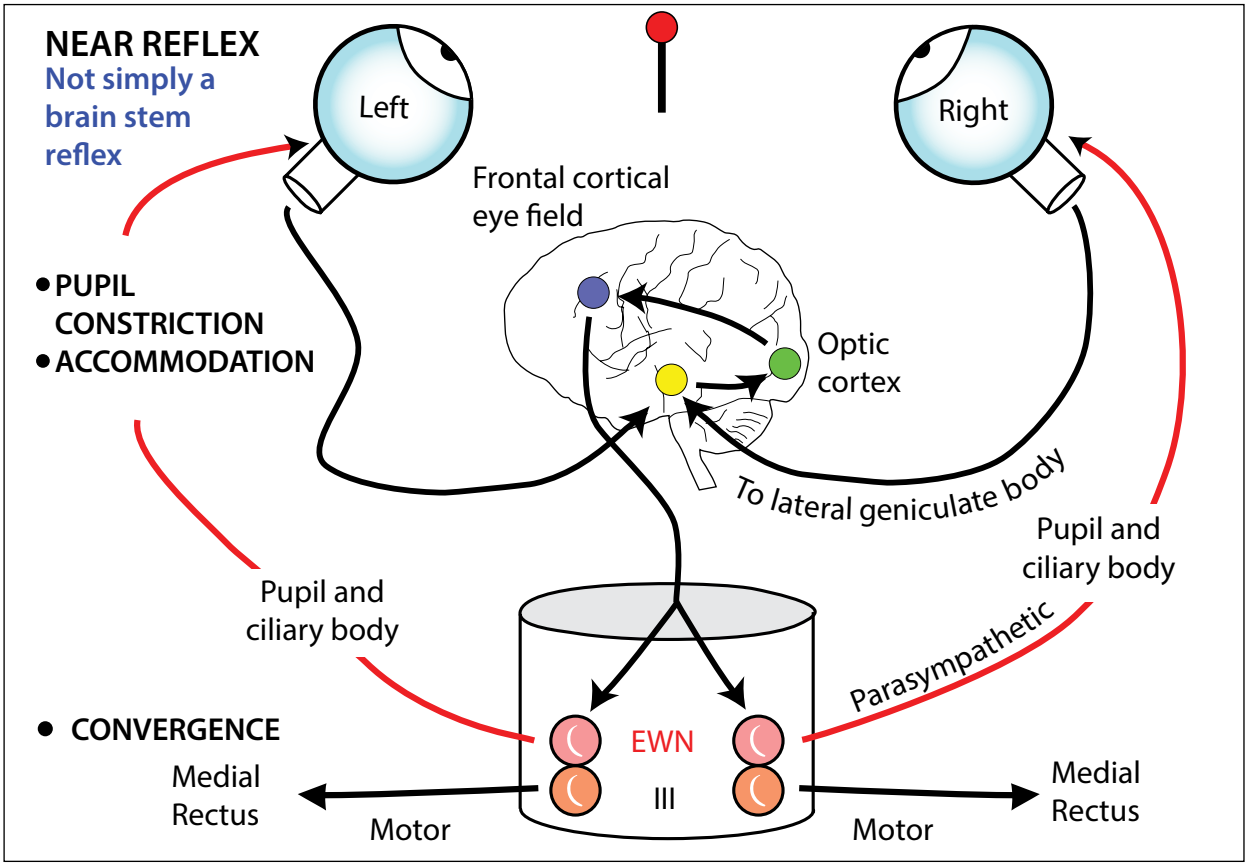


Lesions to:

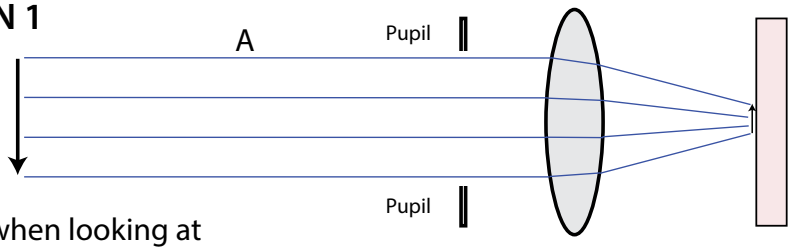
1. Optic nerve on left
2. Oculomotor nerve carrying parasympathetic on left
3. Optic nerve on right
4. Oculomotor nerve carrying parasympathetic on right

Reaction of pupils when light is shone into left eye

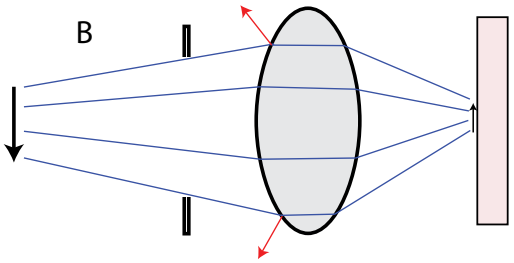
	Left pupil	Right pupil
Normal	yes	yes
Lesion 1	no	no
Lesion 2	no	yes
Lesion 3	yes	yes
Lesion 4		

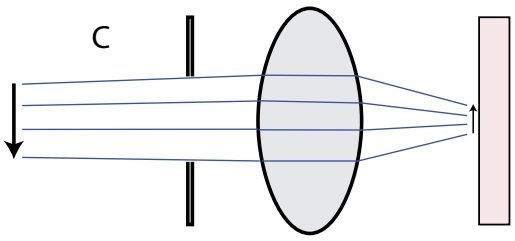


ACCOMMODATION 1



If the pupil is dilated when looking at a near object (B), there is aberration and deflection of the light at the edges of the lens because of the angle it hits it. In (C) the pupil is constricted and light can no longer reach the periphery of the lens. Thus pupillary constriction is an integral part of near vision

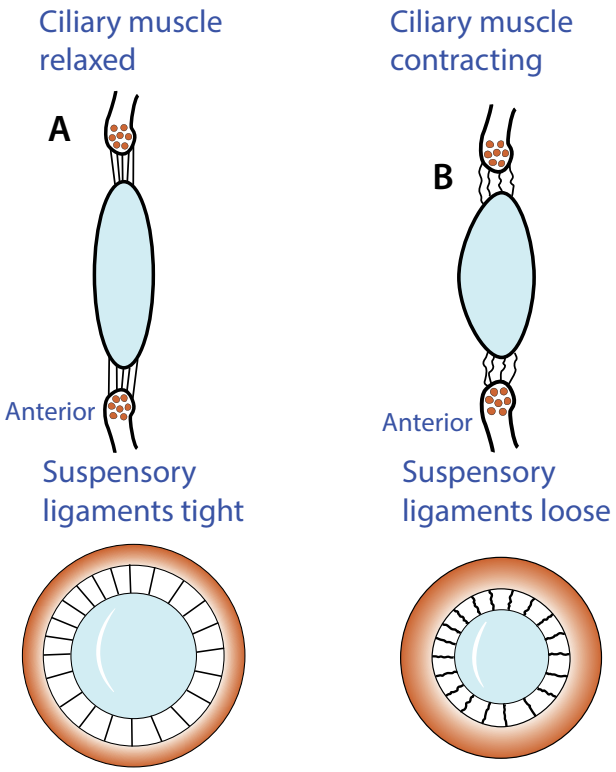




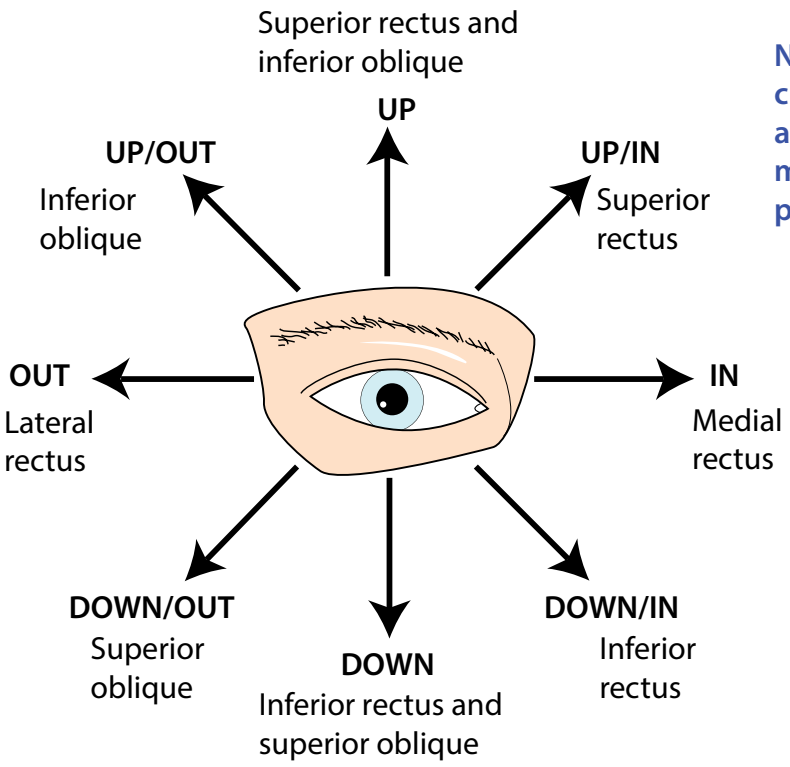
Note: These images concern the lens only and exclude the cornea which contributes 2/3 of the normal refraction

ACCOMMODATION 2

When the ciliary muscle is relaxed the suspensory ligaments holding the lens are tight (A) and they pull the lens into its elongated form.
When the ciliary muscle is contracting, as when looking at near objects, the suspensory ligaments are loose and the lens bulges to its natural shape (B). In this bulging state the increased refraction of the light allows focussing on the retina.
During accommodation there is a little diminution of the diameter of the lens and the bulging is predominantly anterior.



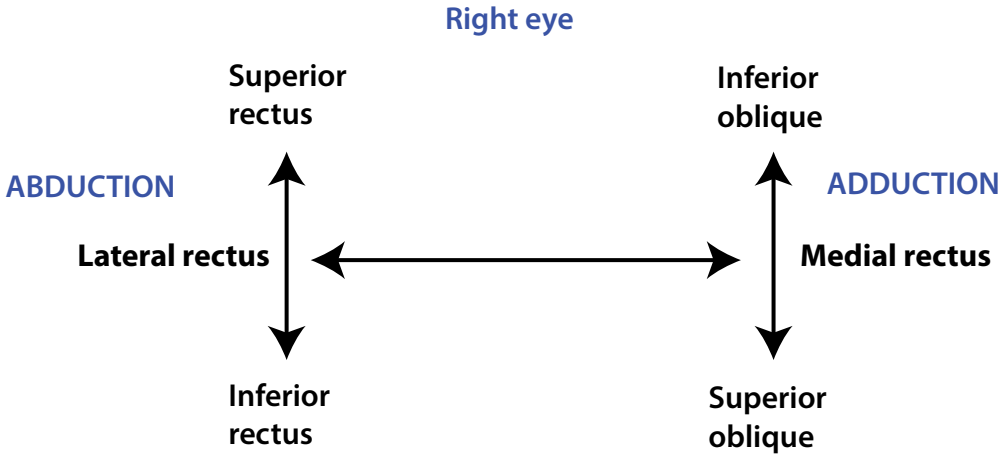
EYE MOVEMENTS PRODUCED BY INDIVIDUAL ISOLATED MUSCLES



Note: This is not relevant to clinical testing but simply and indication of what movement each muscle can produce if acting alone

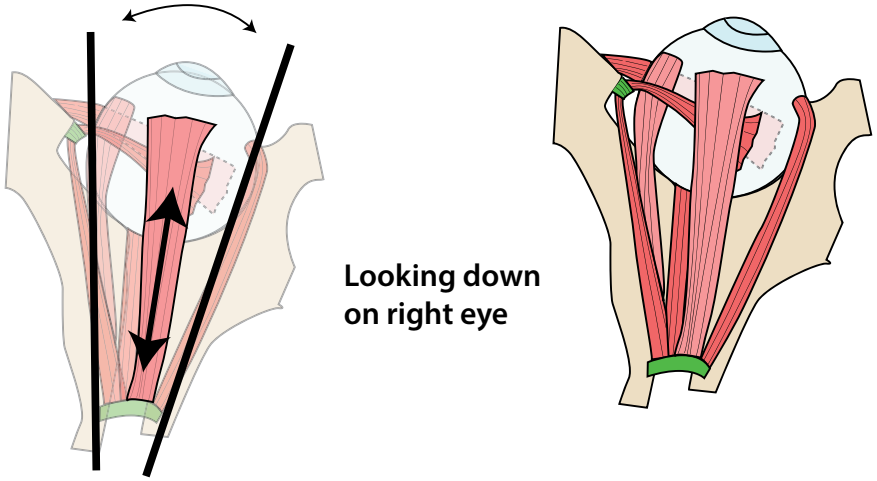
Note: Because of the obliquity of the orbit, the superior and inferior recti pull the eye medially as well as superiorly and inferiorly. Thus the inferior oblique and superior oblique are needed in combination with the recti to move the eye directly upwards and downwards.

CLINICAL TESTING OF EXTRA-OCULAR MUSCLES



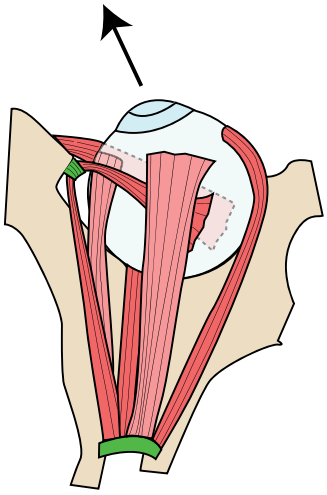
The patient is asked to look inwards (adduct the eye) and whilst adducted, asked to look upwards and downwards. Then these movements are repeated whilst looking outwards (abduction). The muscles that are tested are indicated above. In addition the superior oblique can be tested as indicated in a separate image

OBLIQUE PULL OF SUPERIOR AND INFERIOR RECTI

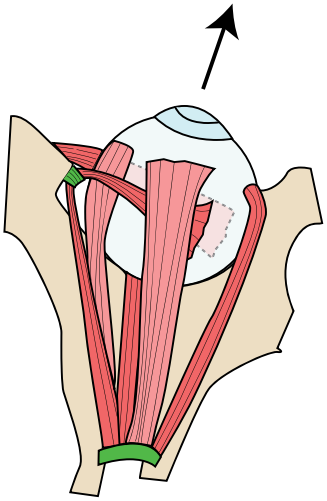


The orbit does not face directly forward but obliquely outwards. This results in the pull of the superior and inferior recti muscles being upwards and downwards but also INWARDS

TORSION



Looking down on right eye



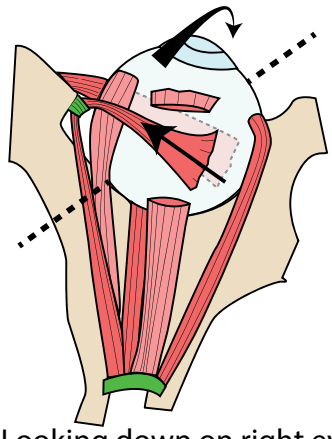
IN ADDUCTION

Superior rectus elevates and intorts
Inferior rectus depresses and extorts
Superior oblique turns eye down and out only
Inferior oblique turns eye up and out only

IN ABDUCTION

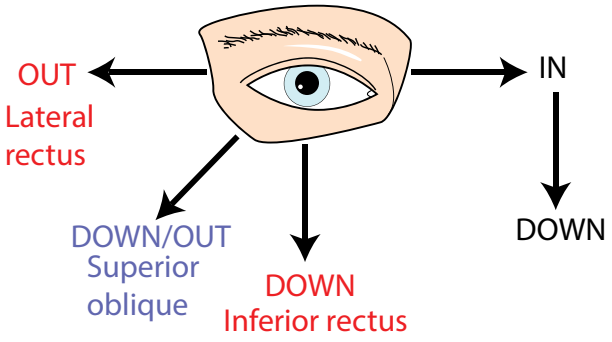
Superior rectus elevates only
Inferior rectus depresses only
Superior oblique turns eye down and out and intorts
Inferior oblique turns eye up and out and extorts

ACTION AND TESTING OF SUPERIOR OBLIQUE



Looking down on right eye

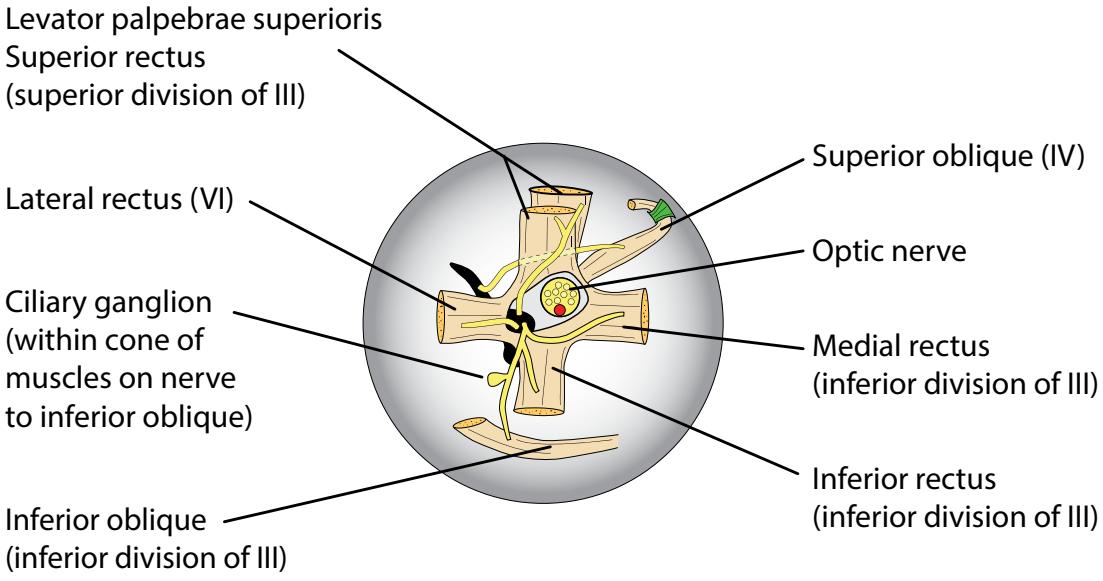
TESTING SUPERIOR OBLIQUE



Acting alone, superior oblique (S.O.) turns the eye down and out. But it cannot be tested by asking the patient to look down and out because a combination of lateral and inferior rectus could also achieve this. These muscle are negated by turning the eye inwards and downwards. When the eye is thus turned the only muscle that can turn the eye down is superior oblique.

Clinically S.O. is tested by tilting the head. If the right S.O. is not functioning, tilting to the right provokes vertical double vision. This diplopia should be counteracted by intorsion mediated by superior rectus and S.O. If S.O. is defective, superior rectus causes excessive elevation resulting in diplopia.

EXTRINSIC EYE MUSCLES OF THE RIGHT EYE IN POSTERIOR ORBIT

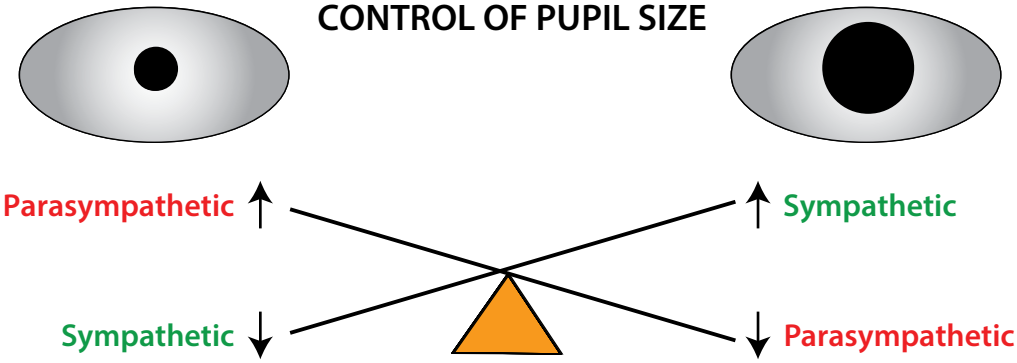


HORNER'S SYNDROME

Left Horner's Syndrome

- Ptosis
- Small pupil
- Dry flushed face
- Apparent enophthalmos

CONTROL OF PUPIL SIZE



PUPIL CONSTRICTION
(Mediated by parasympathetic)

PUPIL DILATATION
(Mediated by sympathetic)

LOSS of sympathetic
(Horner's syndrome)

OR

STIMULATION of parasympathetic
(Light shone in eye)

LOSS of III (parasympathetic)

OR

STIMULATION of sympathetic
(Dark room, fright, etc)

PATHWAYS FOR PUPIL SIZE

PUPIL CONSTRICTION
(Mediated by parasympathetic)

Oculomotor (III)
↓
Ciliary ganglion
↓
Short ciliary nerves

PUPIL DILATATION
(Mediated by sympathetic)

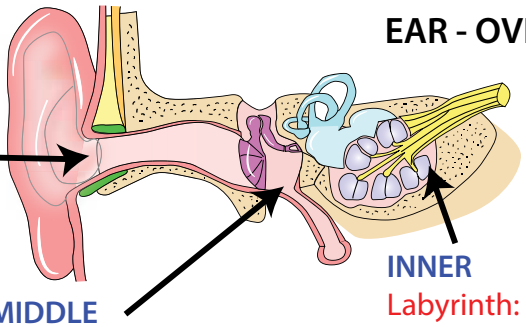
Sympathetic chain
↓
Internal carotid artery
↓
Cavernous sinus
↓
Nasociliary nerve (Va)
↓
Long ciliary nerves

SIZE OF PUPIL AND REACTION TO LIGHT

	CAUSES
SMALL PUPIL normal reaction to light	Old age; Horner's syndrome; Pontine lesion
SMALL PUPIL impaired reaction to light	Opiates; pilocarpine drops for glaucoma; diabetes; Argyll-Robertson pupil of neurosyphilis (accommodation but no reaction to light)
LARGE PUPIL normal reaction to light	Normal finding in children
LARGE PUPIL impaired reaction to light	Atropine drops; Optic and oculomotor nerve lesions; Holmes Adie pupil (myotonic pupil with slow contriction to light and slow dilatation in dark); post anoxia

5.11 Outer, Middle and Inner Ear

EAR - OVERVIEW



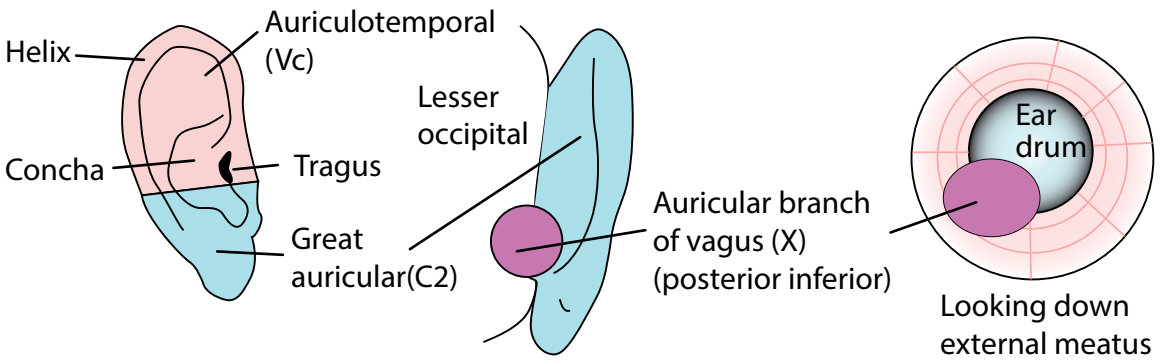
EXTERNAL
- **Pinna**
  - Amplification
  - Localisation
  - Elastic cartilage
  - Vascular
- **External meatus**
  - 3cm long
  - 2/3 bone
  - 1/3 cartilage
  - Curves forwards
  - Hairs
  - Glands
    - Sebaceous
    - Ceruminous
- **Outer eardrum**

MIDDLE
- Ossicles
- Facial nerve
- Chorda tympani
- Inner eardrum
- **Auditory tube**
  - Closed but opens on swallowing to equalise pressure
  - 3.5cm long. 1/3 bone; 2/3 cartilage
  - 30 degrees downwards; 45 degrees ant/med
  - Tubal tonsil at exit in nasopharynx
  - Sensory nerves: Pharyngeal end - phayngeal branch of maxillary (Vb). Middle ear end - glossopharyngeal (IX)

INNER

Labyrinth: contains cochlea, 3 semicircular canals, utricle and saccule

NERVE SUPPLY OF RIGHT PINNA AND EXTERNAL MEATUS

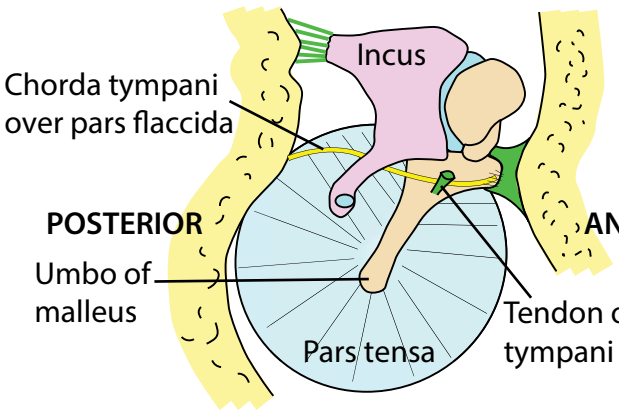


Blood supply:
Posterior auricular
Superficial temporal
Deep auricular (maxillary)

Lymph nodes:
Pre-auricular
Mastoid
Superficial cervical

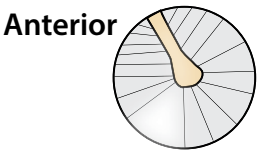
External meatus and outer tympanic membrane are mostly supplied by **auriculotemporal** (Vc) with some **facial (VII)** via tympanic plexus and a small branch of the vagus (see above).
In the **Ramsay- Hunt syndrome** there is recrudescence of the dormant varicella virus in the geniculate ganglion giving herpes zoster (shingles) in the external meatus.

MIDDLE EAR - LEFT TYMPANIC MEMBRANE



Viewed from inside middle ear

View down an auroscope

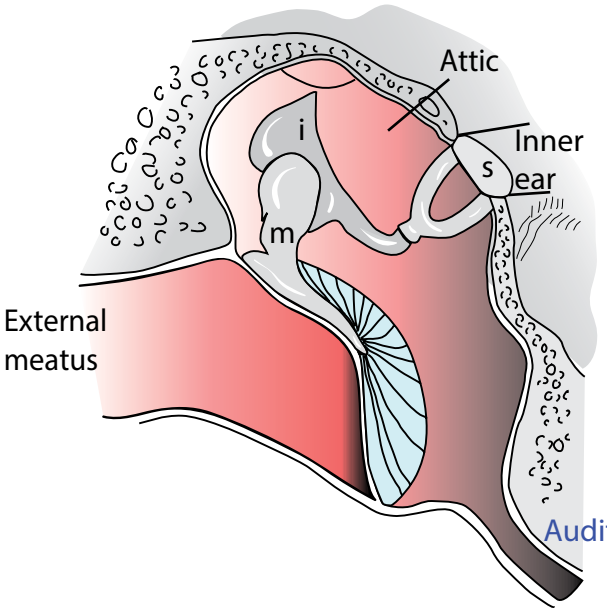


Cone of light (antero-inferior)

Tympanic membrane

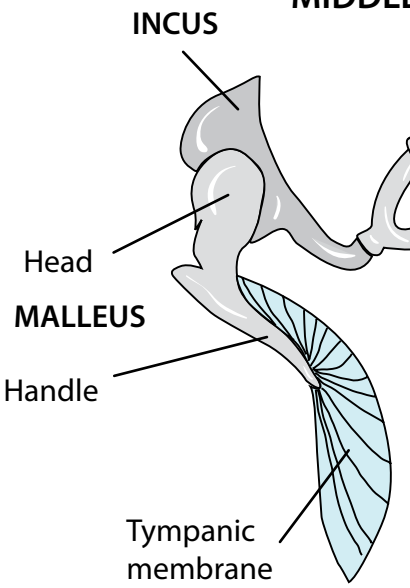
- 1cm diameter. Pearly grey and shiny
- **3 layers: Inner:** Mucosal surface of low columnar epithelium embryologically from first pouch. **Middle:** Fibrous. **Outer:** Squamous surface embryologically from first cleft.
- 55 degrees to horizontal. Concave outwards. Faces downwards, forwards and laterally
- Pulled inwards by tensor tympani
- **Sensory supply: Inner** - glossopharyngeal (IX). **Outer** - auriculotemporal (Vc)
- Vibrates with incoming sound. Needs equal air pressure on each side of it

MIDDLE EAR



Mucosa covers all the walls of the middle ear and is supplied by glossopharyngeal nerve (IX)

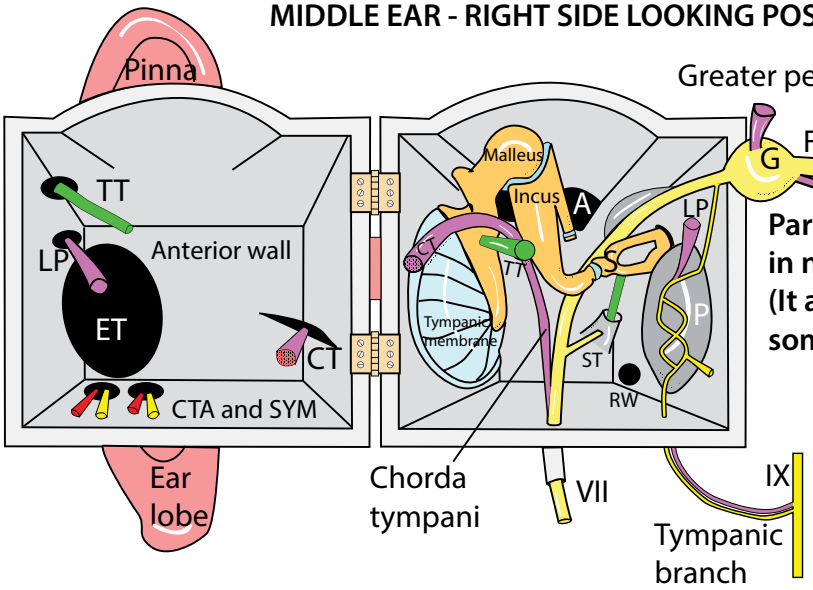
MIDDLE EAR - OSSICLES



- They increase the amplitude of the vibrations 15-20 times because of:
  - a. Leverage
  - b. Eardrum to oval window ratio
- Synovial joints between them
- Almost adult size at birth

For hearing movements (vibration measured in angstroms), the ossicles act together as a single block. For pressure changes (measured in millimetres), the ossicles flex at the joints between them

MIDDLE EAR - RIGHT SIDE LOOKING POSTERIORLY

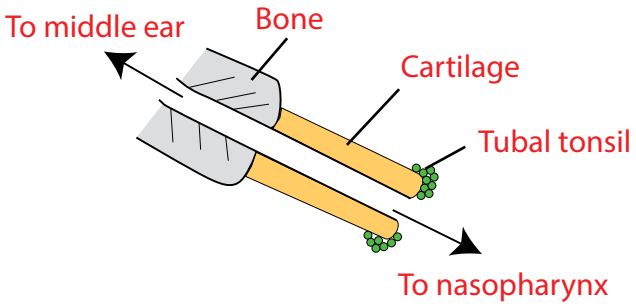


Parasympathetic in nervus intermedius (It also carries taste and some sensory fibres)

A - Aditus to mastoid air sinus
CTA - Caroticotympanic arteries
CT - Chorda tympani
ET - Eustachian tube
G - Geniculate ganglion
LP - lesser petrosal nerve
P - Promontory (last turn of cochlea)
RW - Round window
TT - Tensor tympani
SYM - Sympathetic fibres
S - Stapes
ST - stapedius

The carotico-tympanic arteries bring in blood supply and sympathetics for the tympanic plexus on the promontory

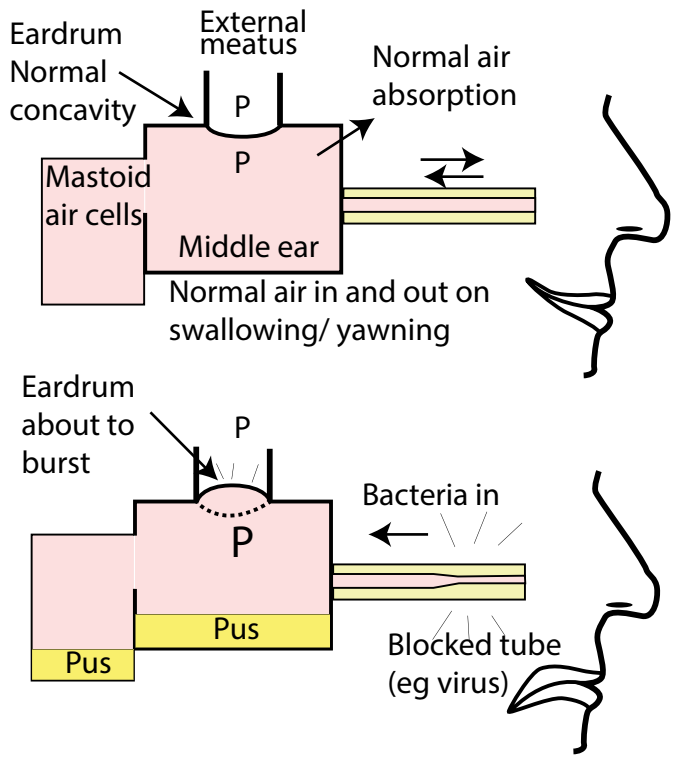
MIDDLE EAR - AUDITORY (EUSTACHIAN) TUBE



NOTES

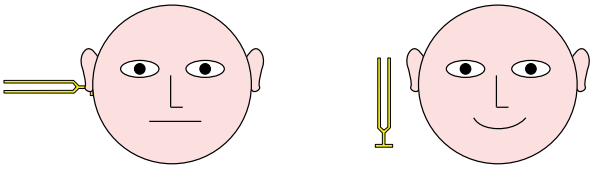
- 3-3.5cm long. Develops from 1st pharyngeal pouch
- **Arterial supply:** Ascending pharyngeal and middle meningeal
- **Angles:** 30 degrees downwards, 45 degrees anteromedially
- Tubal tonsil at exit in nasopharynx
- 1/3 bone: 2/3 cartilage
- **Opens:** On swallowing to equalise pressure
- **Mucosa:** Valve- like
- **Sensation: Lower part:** Pharyngeal branch of maxillary nerve (Vb). **Upper part:** Glossopharyngeal (IX) (hence referred pain to middle ear from tonsils and oropharynx)
- **Columnar epithelium:** Bony part in petrous temporal bone
- **Ciliated columnar epithelium:** Cartilaginous part in squamotympanic fissure
- **Muscles for opening:** Salpingopharyngeus, levator palati, tensor palati

MIDDLE EAR - AUDITORY (EUSTACHIAN) TUBE - EFFECT OF BLOCKAGE

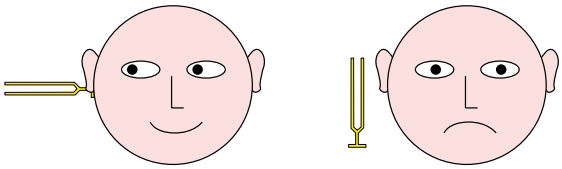


Effects of blocked auditory tube:
1. At first air is still absorbed - drum sucked in more. 2. Giving poor ossicle/drum movement - deafness. 3. Then viral/bacterial exudate becomes infected. 4. Middle ear +/- mastoid air cells fill with pus (otitis media). 5. Then pressure rises - drum bulges outwards, may burst. 6. Infection may spread to - inner ear, venous sinuses, extradural, subdural, meninges, brain abscess. 7. **THEN EITHER:**
a. Drains and heals or b. Becomes chronic, +/- glue ear or cholesteatoma or c. Persistent perforation of drum, +/- necrosis of ossicles

RINNE TEST FOR INDIVIDUAL EAR DEAFNESS

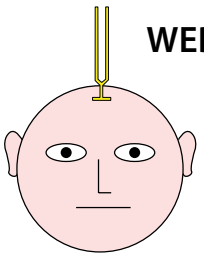


To compare AIR to BONE conduction in the RIGHT ear, the vibrating tuning fork is held first against the mastoid bone, then outside the external meatus. The patient is asked which position produces the louder sound. If it is louder at the meatus then AIR conduction (AC) is better than BONE conduction (BC). The RINNE test is positive. The Rinne test will be positive both in a patient with normal hearing and in a patient with sensori-neural loss

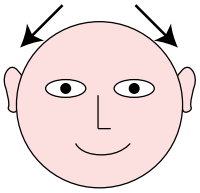


In **CONDUCTIVE LOSS** sound is heard louder via BONE than in AIR. Rinne negative

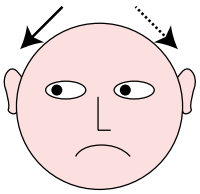
WEBER TEST FOR WHEN THERE IS DEAFNESS IN ONLY ONE EAR



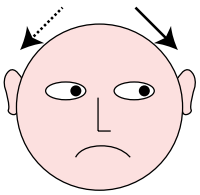
The vibrating tuning fork is placed on the patient's forehead in the midline and asked in which ear the sound is louder



The normal response is to hear equally in the two ears

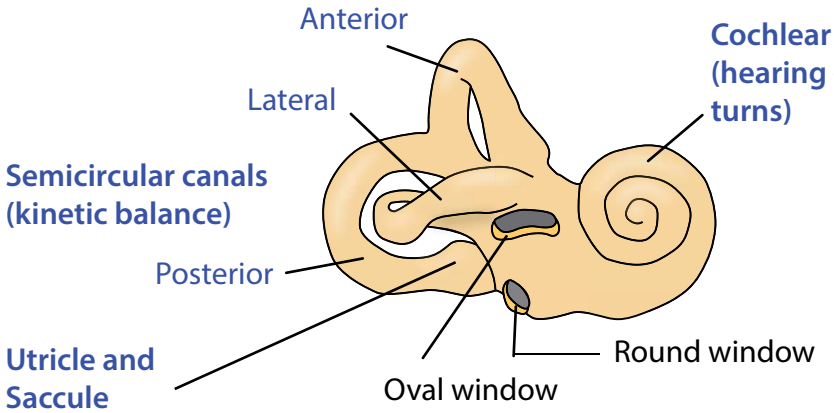


If there is a **CONDUCTIVE LOSS** in the RIGHT ear, the sound will be heard louder in the RIGHT (deaf) ear by passing through bone to the inner ear, free of any ambient (background) noise. The likely explanation is that an ear with a conductive deafness is protected from any ambient sounds whereas the other ear is not.



If the patient has a **SENSORI-NEURAL LOSS** in the RIGHT ear the sound will be heard louder in the normal ear

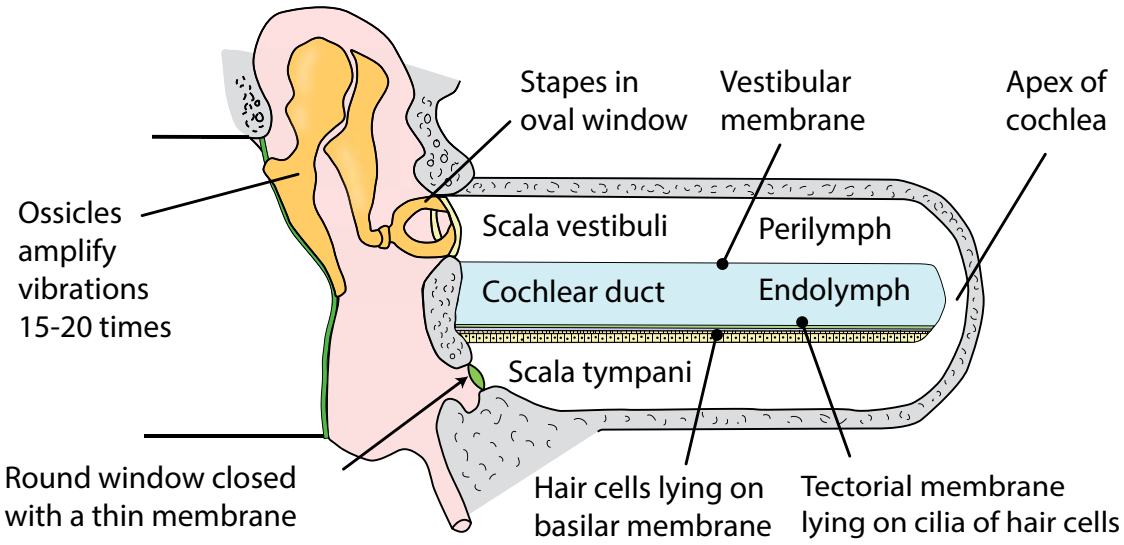
INNER EAR - BONY LABYRINTH



Semicircular canals sense angular acceleration such as fairground rides.
Utricle and saccule sense horizontal and vertical acceleraton such as fast cars and lifts (elevators).

- Full size at birth
- In petrous temporal bone
- One continuous cavity
- For hearing and balance
- Vestibulocochlear nerve
- **Blood:** Labyrinthine artery

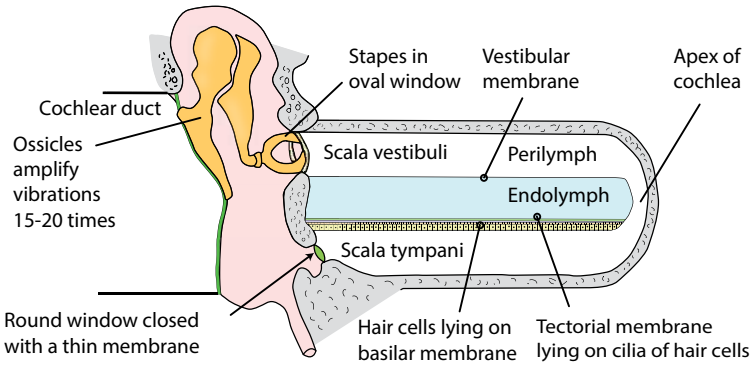
INNER EAR - (Cochlea straightened out to aid understanding)



Perilymph: Made from CSF. Returns into CSF at perilymphatic duct (near jugular foramen).

Endolymph: Made in vascular part of membranous layer. Returns by being absorbed by epithelium of endolympatic sac

INNER EAR - (Cochlea straightened out to aid understanding)



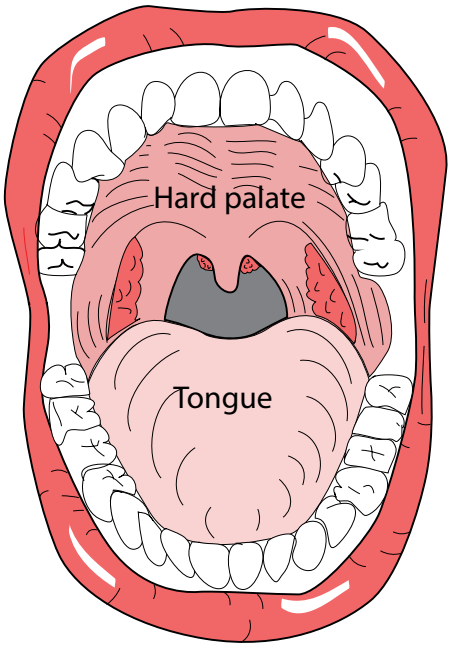
HEARING CONDUCTION

Sound waves → Pinna → External meatus → Tympanic membrane → Ossicles → Round window → Vibrations in perilymph → Travelling wave in basilar membrane → Outer hair cells - mechanically amplify the localised wave peak → Nearby inner hair cells depolarise selected cochlear neurones → Auditory cortex via vestibulocochlear nerve (VIII)

Tonotopic organisation means that low pitches are perceived at the apex of the cochlear spiral and high pitches at the base

5.12 Mouth and Mandible

ORAL CAVITY - MOUTH

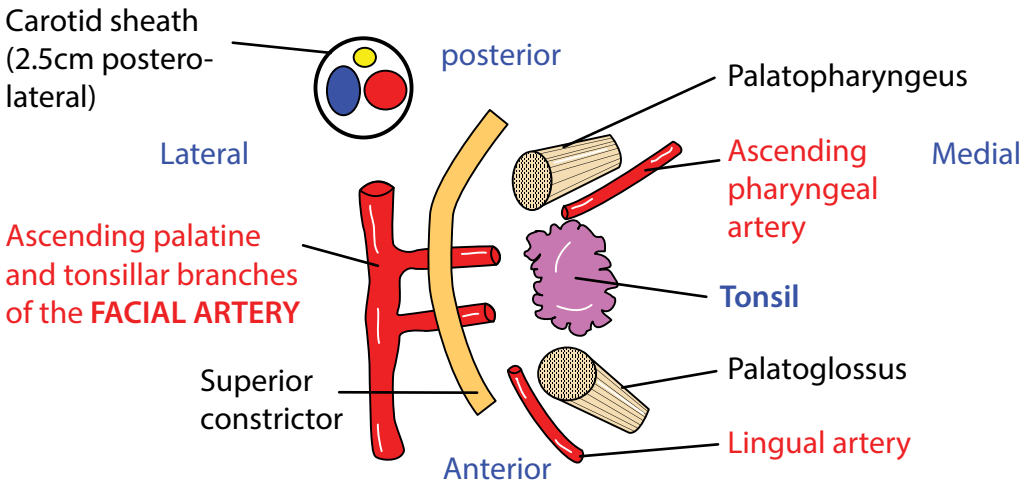


Stratified squamous epithelium
Pierced by salivary gland ducts
Nerve: Buccal and mental
Vestibule: Between teeth and gums, empted by buccinator

TEETH: 32. All but molars erupted by 13yrs.
Incisors 8
Canines 4
Premolars 8
Molars 8 (erupt approx 18yrs)
Deciduous: erupt 7-24 months
Teeth Ns: Superior alveolar (Vb)
Inferior alveolar (Vc)

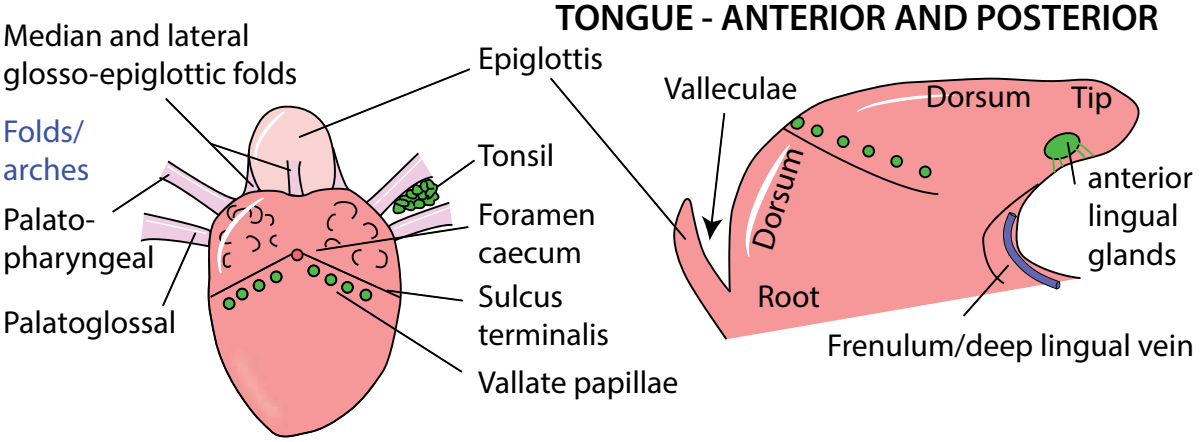
PALATINE TONSIL BETWEEN PALATOGLOSSAL AND PALATOPHARYNGEAL ARCHES

RIGHT PALATINE TONSIL
(viewed from above)



Lymphoid tissue: In tonsillar fossa with 20 tonsillar crypts. **Surface marking:** Medial to lower masseter. **Between:** Palatoglossal and palatopharyngeal arches. **Superior:** Soft palate. **Inferior:** Tongue. **Lateral:** Capsule, superior constrictor, facial artery and branches. **Lymph:** Deep cervical and jugulodigastric. **Veins:** Pharyngeal plexus of veins. **Nerves:** Glossopharyngeal (referred pain to middle ear)

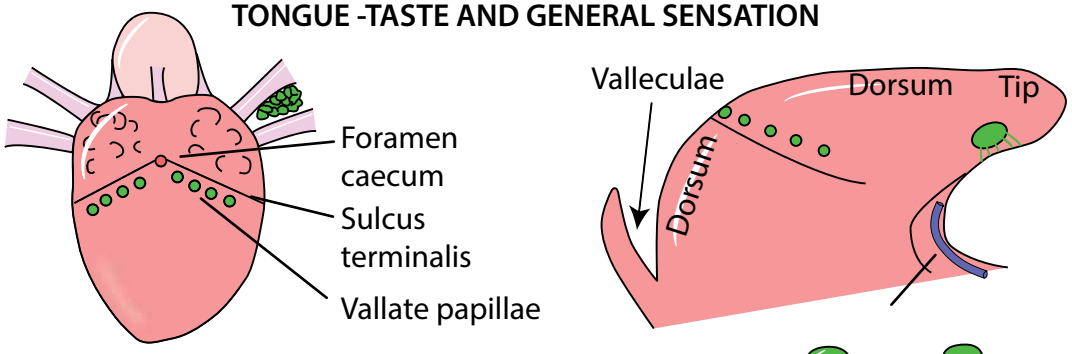
TONGUE - ANTERIOR AND POSTERIOR



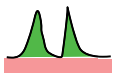
POSTERIOR 1/3
Oropharynx. smooth mucosa for swallowing. No papillae. Lingual tonsil. Serous/mucous glands
Taste/general sensation:
Glossopharyngeal nerve (IX)
Artery: Lingual
Lymph nodes: Jugulo-omohyoid and deep cervical

ANTERIOR 2/3
Oral cavity. Papillae (filiform, fungiform and vallate) for grip/taste.
Stratified, keratinising squamous epithelium. Glands on tip and sides only
General sensation: Lingual (Vc)
Artery: Lingual
Lymph nodes: Tip - submental bilateral. Dorsum - unilateral to submandibular

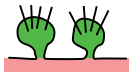
TONGUE -TASTE AND GENERAL SENSATION



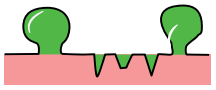
PAPILLAE



Filiform for grip,keratin tips - pink after chewing, white then brown when dry



Fungiform Taste buds



Vallate with crypts for taste and serous glands

TASTE: There are fungiform papillae throughout the anterior 2/3 of the tongue, supplied by the chorda tympani. The vallate papillae are aligned just anterior to the sulcus terminalis and, although they are in the anterior 2/3 of the tongue, they are supplied by the glossopharyngeal nerve (IX). There are also fungiform papillae in the arches lateral to the posterior third of the tongue (but not on its surface) which are also supplied by the glossopharyngeal nerve (IX). There are also a few taste buds in the vallecula supplied by the internal branch of the superior laryngeal nerve.

TONGUE - SENSATION AND TASTE (SUMMARY)

	SOMATIC SENSATION	TASTE	SECRETOMOTOR
ANTERIOR 2/3	Lingual (Vc)	Chorda tympani carried by VII	Chorda tympani carried by VII to anterior lingual glands
POSTERIOR 1/3 + VALLATE PAPILLAE	Glosso-pharyngeal (IX)	Glosso-pharyngeal (IX)	Glosso-pharyngeal (IX)
VALLECULAE	Glosso-pharyngeal (IX)	Internal branch of superior laryngeal nerve (X)	Glosso-pharyngeal (IX)

Note: Sympathetic supply to tongue is from superior cervical ganglion via lingual artery

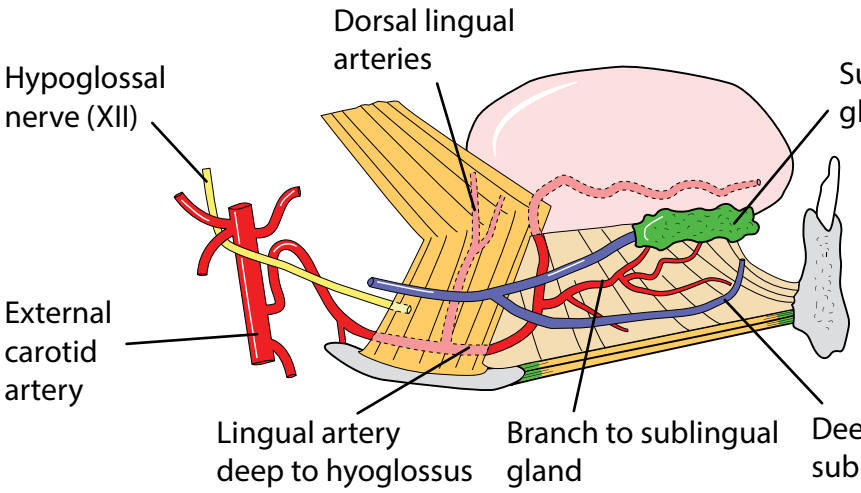
TONGUE - MUSCLES

All tongue muscles are supplied by the hypoglossal nerve except palatoglossus which is supplied by the pharyngeal plexus (IX, X and sympathetic)

Hyoglossus:	Hypoglossal nerve (XII)
Genioglossus:	Hypoglossal nerve (XII)
Styloglossus:	Hypoglossal nerve (XII)
Palatoglossus:	Pharyngeal plexus (IX, X and sympathetic)
Intrinsic muscles:	Hypoglossal nerve (XII)

Note: The intrinsic muscles of the tongue (Superior/inferior longitudinal, transverse and vertical) are not attached to bone)

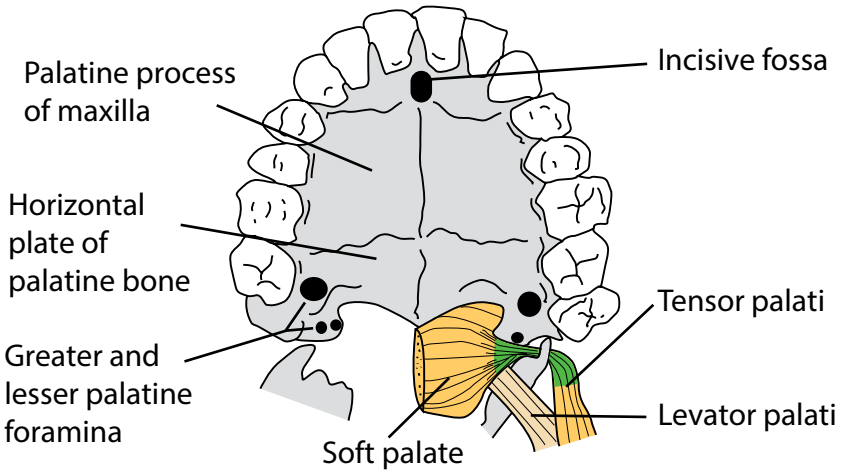
TONGUE - BLOOD SUPPLY AND LYMPH DRAINAGE



LYMPH

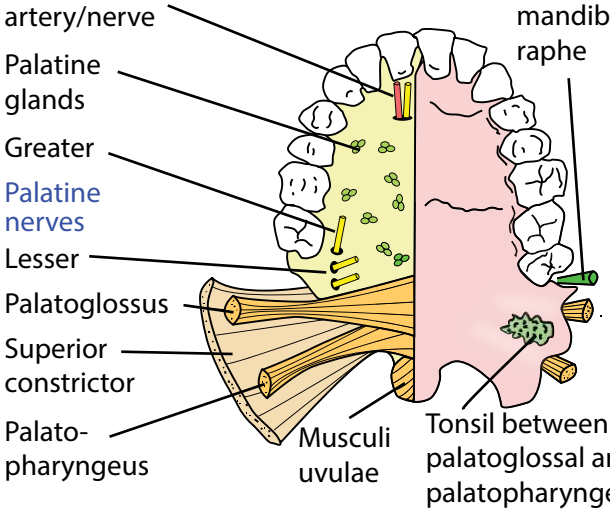
- **Tip** to submental glands bilaterally
- **Dorsum** to submandibular mostly unilaterally
- **Posterior** to jugulo-omohyoid and deep cervical

HARD PALATE



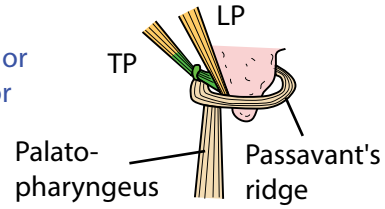
- Mucoperiosteum (mucosa + periosteum)
- **Sharpey's fibres:** Collagen fibres from periosteum into pits on bone
- **Blood supply:** Greater palatine artery
- **Venous drainage:** Pterygoid plexus
- **Lymph:** Retropharyngeal and deep cervical nodes
- **Nerve supply:** Greater palatine and nasopalatine nerves

SOFT PALATE



Epithelium: Stratified squamous
Blood: Lesser palatine (maxillary): Ascending palatine (facial): Palatine branch of ascending pharyngeal (external carotid)
Veins: Pharyngeal and pterygoid plexus
Lymph: Retropharyngeal and anterosuperior deep cervical
Nerves: **Secretomotor** - Vb via pterygopalatine ganglion
Sensation - Vb, lesser palatine, glossopharyngeal (IX)
Taste - Greater and lesser palatine to greater petrosal
Function: closes nasopharynx

Passavant's ridge is a circular, sphincter- like part of either palatopharyngeus or superior constrictor

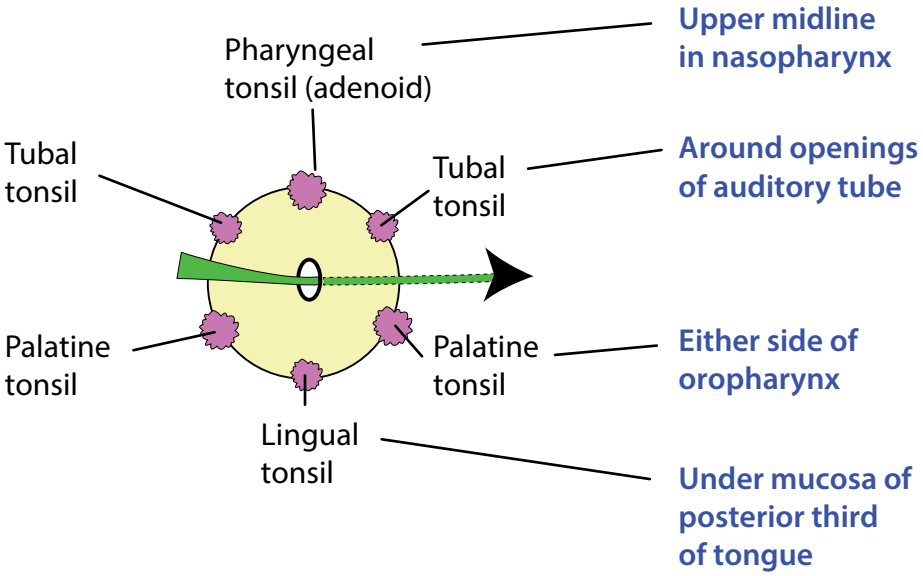


Consists of:

- Aponeurosis
- Tensor palati (TP)
- Levator palati (LP)
- Palatoglossus
- Palatopharyngeus
- Muscles of uvula
- Mucosa with mucous and serous glands and a few taste buds

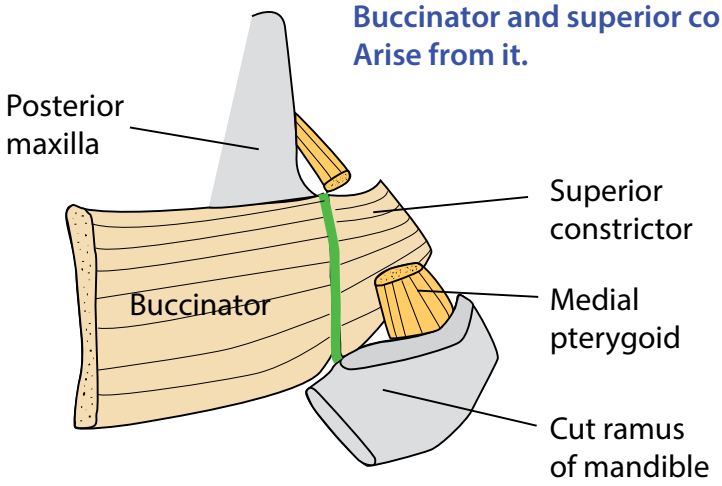
WALDEYER'S RING

An interrupted circle of protective lymphoid tissue at the upper ends of the respiratory and alimentary tracts

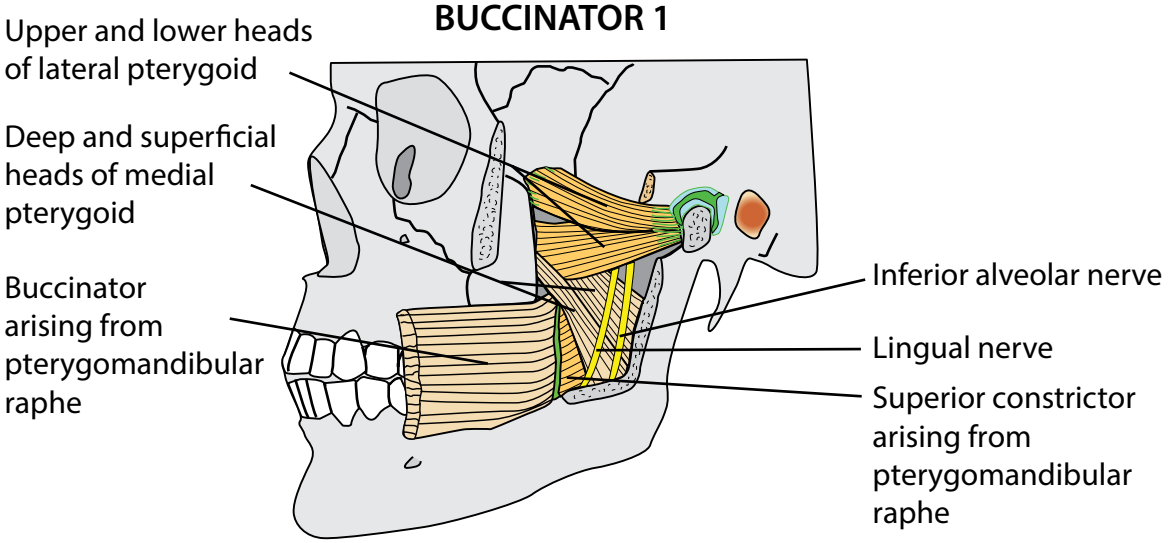


PTERYGOMANDIBULAR RAPHÉ

From pterygoid hamulus on medial pterygoid plate to posterior aspect of mylohyoid line on mandible. Buccinator and superior constrictor Arise from it.



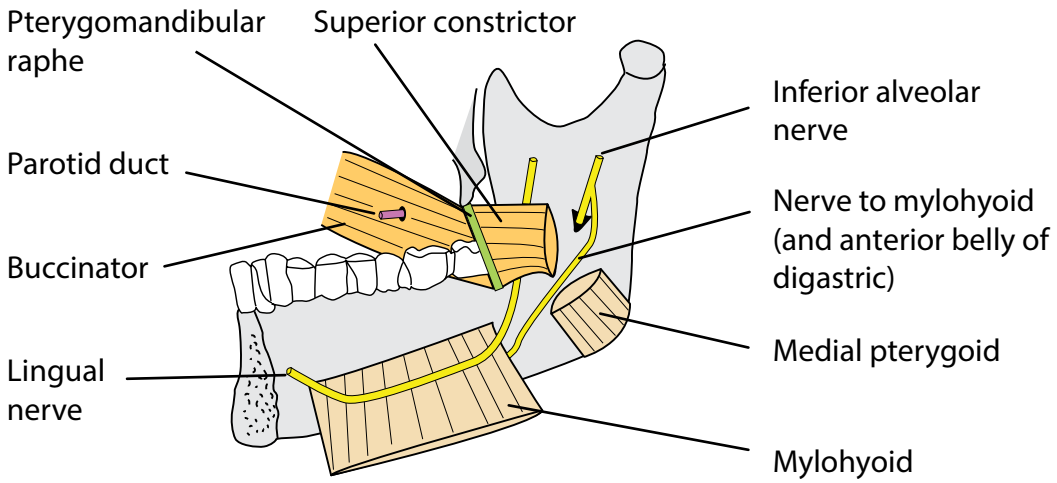
BUCCINATOR 1



Origin: Both jaws opposite 1st molar teeth and pterygomandibular raphe and pterygomaxillary ligament
Insertion: Modiolus
Action: Helps chewing, returns food to mouth from cheek pouches
Nerve supply: Facial (VII) - buccal branches. Proprioceptive afferent fibres via buccal branch of Vc

BUCCINATOR 2

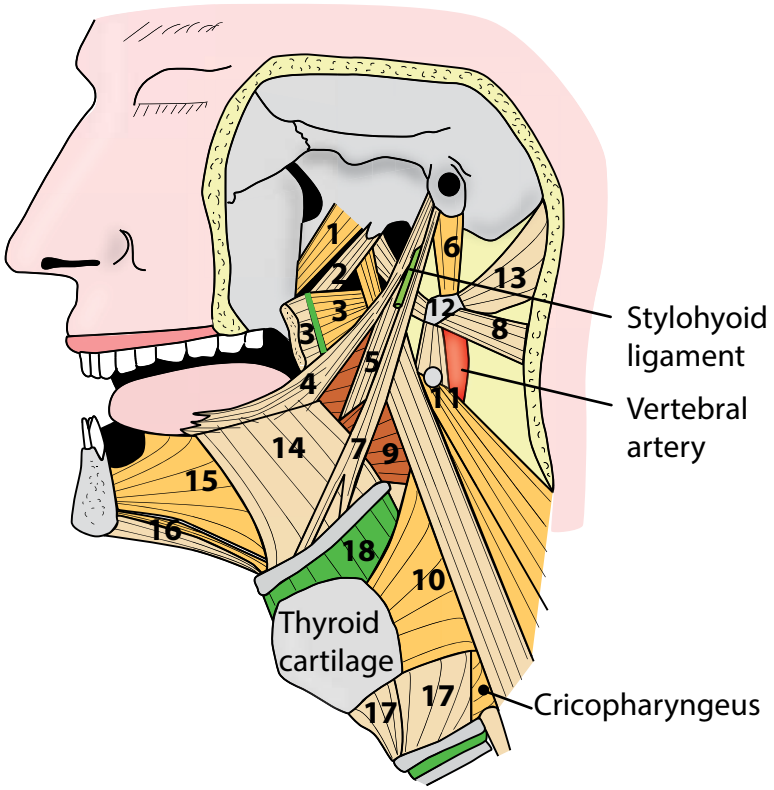
Viewed from medial aspect of mandible



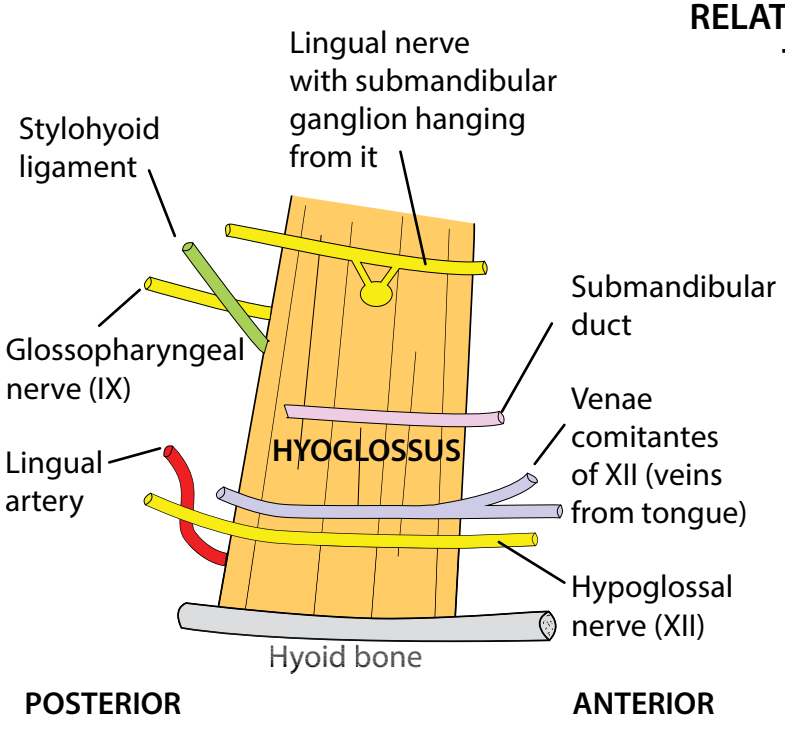
The pterygomandibular raphe is fibrous tissue extending from the pterygoid hamulus to the posterior end of the mylohyoid line. It is a landmark for dentists to anaesthetise the lingual nerve

MUSCLES OF TONGUE, MOUTH AND NECK

1. Tensor palati
2. Levator palati
3. Buccinator and superior contrictor from pterygo-mandibular raphe
4. Styloglossus
5. Stylopharyngeus
6. Rectus capitis lateralis
7. Stylohyoid
8. Inferior oblique
9. Middle constrictor
10. Thyropharyngeus
11. Transverse process of axis
12. Transverse process of atlas
13. Superior oblique
14. Hyoglossus
15. Genioglossus
16. Geniohyoid/mylohyoid
17. Cricothyroid
18. Thyrohyoid membrane

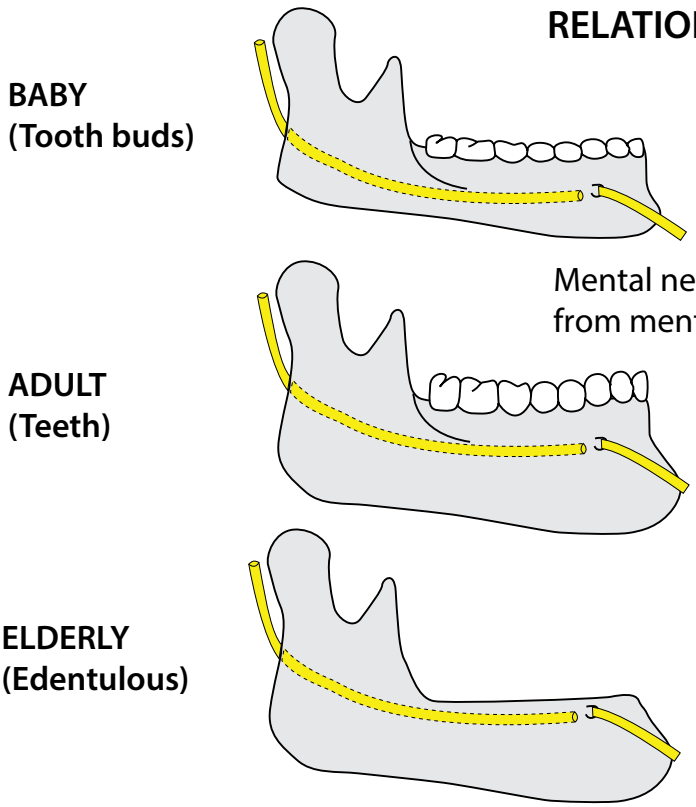


RELATIONS OF STRUCTURES TO HYOGLOSSUS



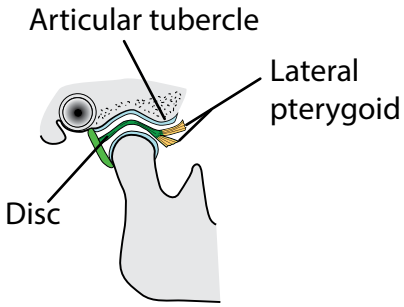
- The mylohyoid muscle (not shown) overlaps the anterior edge of hyoglossus.
- Hyoglossus is supplied by the hypoglossal nerve as are all the muscles of the tongue except palatoglossus (pharyngeal plexus-IX, X, Sympathetic).
- Further anteriorly, under the mylohyoid, the lingual nerve passes lateral to the submandibular duct, then dips under it to appear on its medial side to enter the tongue.
- The venae comitantes of the hypoglossal nerve pass posteriorly to join the facial vein.

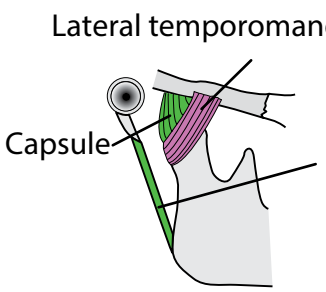
INFERIOR ALVEOLAR NERVE: RELATIONS WITH MANDIBLE



In elderly people the inferior alveolar nerve come to lie nearer the upper aspect of the mandible due to loss of teeth and bone erosion. Irritation of the nerve may lead to pain.

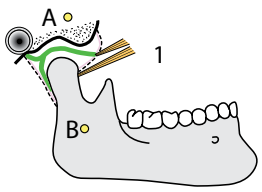
TEMPOROMANDIBULAR JOINT



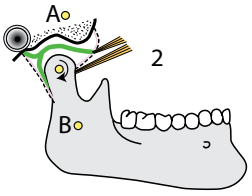


Synovial, condyloid, hemicylindrical, atypical (fibrocartilage on surfaces)
Fibrocartilaginous disc, synovial membrane lines capsule
Nerve: Auriculotemporal and nerve to masseter
Between: Mandible and mandibular fossa of squamous temporal bone
Disc: Moves forward with head of mandible
Capsule: Attached to neck of mandible and articular tubercle. Strong but lax at rest
Lateral temporomandibular ligament: Zygomatic arch to posterior neck and ramus of mandible. Fuses with capsule, lax at rest, tightens with any movement

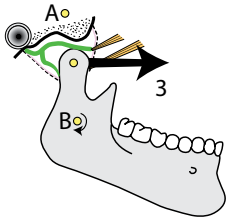
MOVEMENTS OF TEMPOROMANDIBULAR JOINT



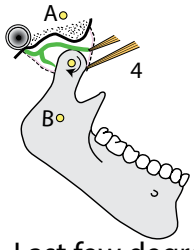
Points A and B are the 2 ends of the sphenomandibular ligament which is isometric at all joint positions. Axis for opening is through lingula (B)



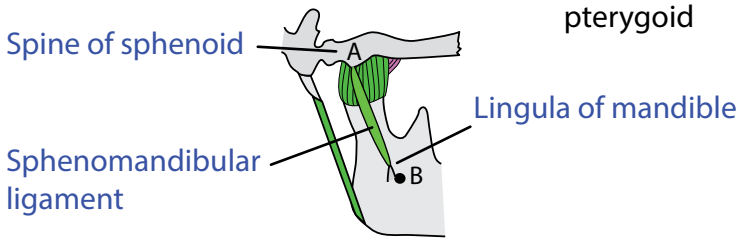
First few degrees of opening are rotation only in lower cavity.



Majority of opening is rotation in lower joint cavity but with anterior displacement of head of mandible in upper joint cavity onto articular tubercle by action of lateral pterygoid



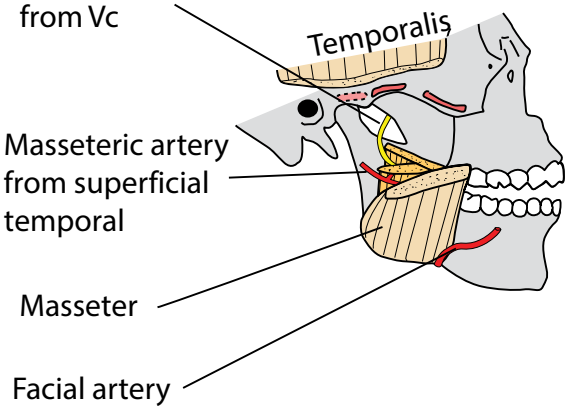
Last few degrees of opening are by further rotation in lower joint cavity only

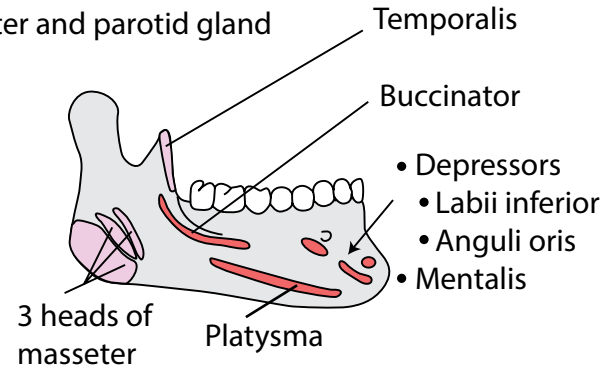


THE JOINT IS MOST STABLE WHEN CLOSED

PAROTID REGION AND MASSETER

Definition: Anterior and inferior to ear
Features: Masseter and parotid gland



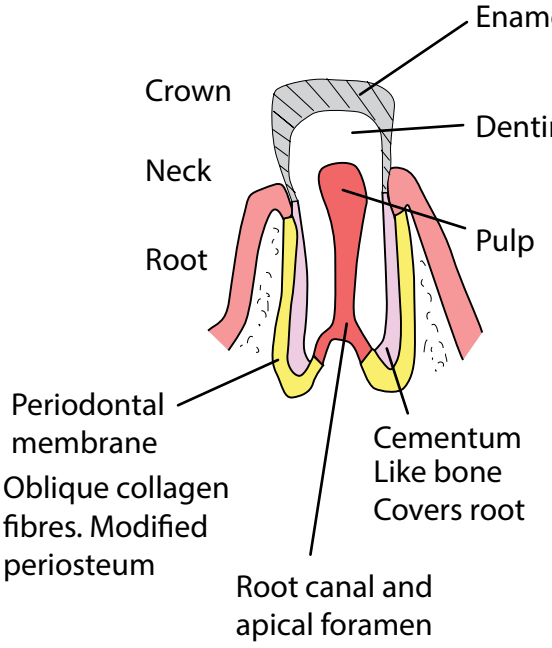


MASSETER

Origin: 3 heads from zygomatic arch
1. Superficial - anterior 2/3
2. Intermediate - middle 1/3
3. Deep - Deep surface of posterior arch

Insertion: Ramus/angle of mandible
Action: Closes jaw
Nerve: Masseteric branch of mandibular (Vc)

TEETH - 1



Calcified ++
hardest tissue in body

Avascular. Calcified ++.
Harder than bone. Contains dentinal tubules. Produced by odontoblasts

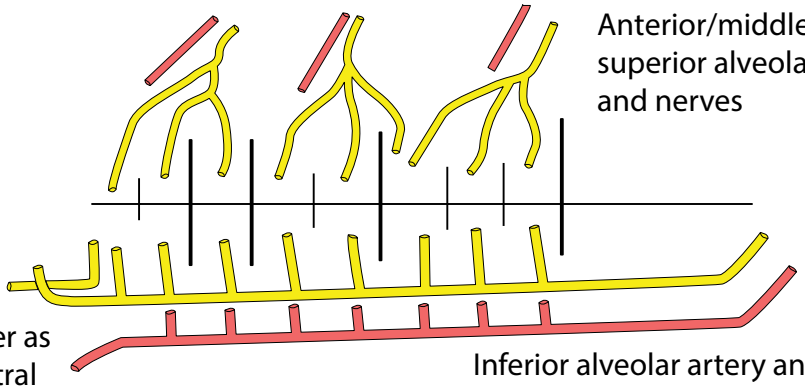
Loose fibrous tissue, blood, lymphatics, nerves. Cavity lined by odontoblasts - tall columnar

Development

- Budding of mouth ectoderm gives enamel
- Mesoderm is evoked to produce dentine and cementum
- Ameloblasts give enamel
- Mesoderm gives dental papillae which give odontoblasts which give dentine
- Dental papilla also gives pulp

TEETH - 3

NERVE AND BLOOD SUPPLY



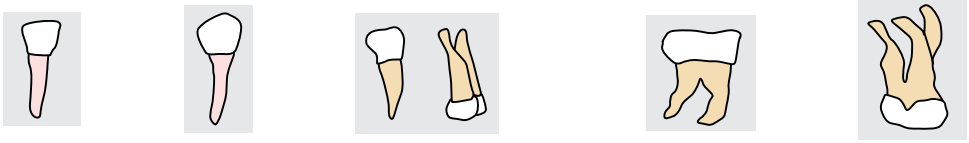
Anterior/middle/posterior superior alveolar arteries and nerves

Cross- over as far as central incisor

Inferior alveolar artery and nerve

Note: The further posterior that anaesthesia is needed the more a nerve block is required and the less efficient is local infiltration because of bone porosity

TEETH - 2



	INCISOR	CANINE	PREMOLAR		MOLAR	
ADULT NUMBER	2	1	2		3	
			lower	upper	lower	upper
ROOTS	1	1	1st and 2nd:1	1st:2 2nd: 1	2	3
CUSPS	1	1	2		5	4

TOTAL IN ADULTS 8 X 2 =16 X 2 = 32

ERUPTIONS

	Incisors	Canines	Premolars	Molars	
Deciduous (5x2=10x2=20)	7 8	18		12 24	months
	6 9	18		12 24	
Permanent	7 8	11	9 10	6 12 18+	years
	7 8	11	9 10		

5.13 Nose and Face

EXTERNAL NOSE AND NASAL CAVITY

EXTERNAL NOSE is fibrofatty tissue supported by 5 cartilages and two small bones

NASAL CAVITY

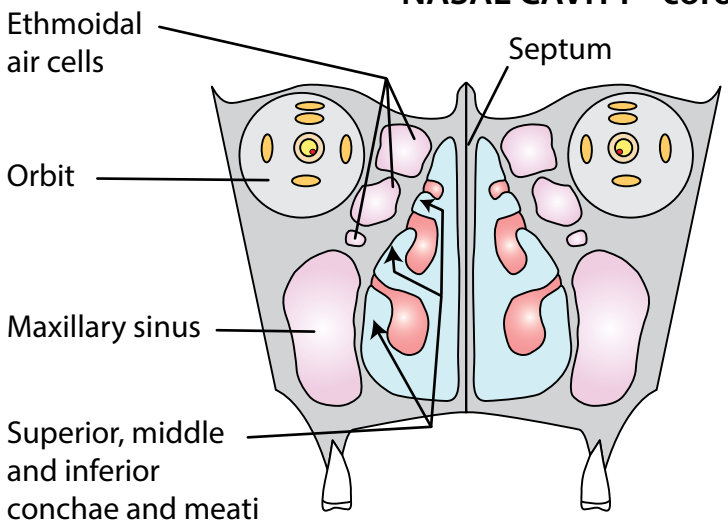
For:
- Breathing (stops during swallowing)
- Warming, moistening and filtering the air
- Sense of smell

Structure:
- Conchae and sinuses increase the surface area, the epithelium is vascular, there are cilia and mucus is secreted

Nerve supply:
- External nasal (terminal anterior ethmoidal) Va
- Supratrochlear (frontal) Va
- Infratrochlear (nasociliary) Va
- Infra-orbital (maxillary) Vb

Blood supply:
- Dorsal nasal (ophthalmic)
- External nasal (anterior ethmoidal)
- Facial (lateral nasal and septal branches)

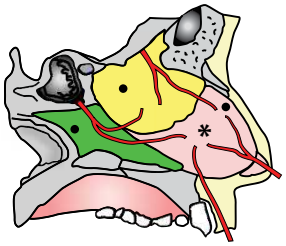
NASAL CAVITY - coronal view

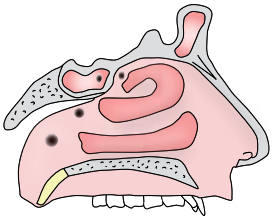


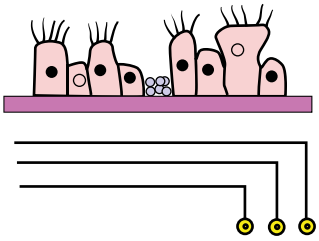
Sensory nerves: Olfactory (I), ophthalmic (Va), maxillary (Vb)
Parasympathetic secretomotor nerves: Profuse from pterygo-palatine ganglion - carried by branches of maxillary nerve.
Mucosa: Nares - skin and hair.
Respiratory - pseudostratified ciliated columnar epithelium with goblet cells and serous acini. Dense cilia propel mucus

- Nasal cavity extends from nares to choana
- **Floor:** Hard palate
- **Roof:** Sphenoid and ethmoid
- **Medial wall:** Septum
- **Lateral wall:** Conchae

NASAL CAVITY





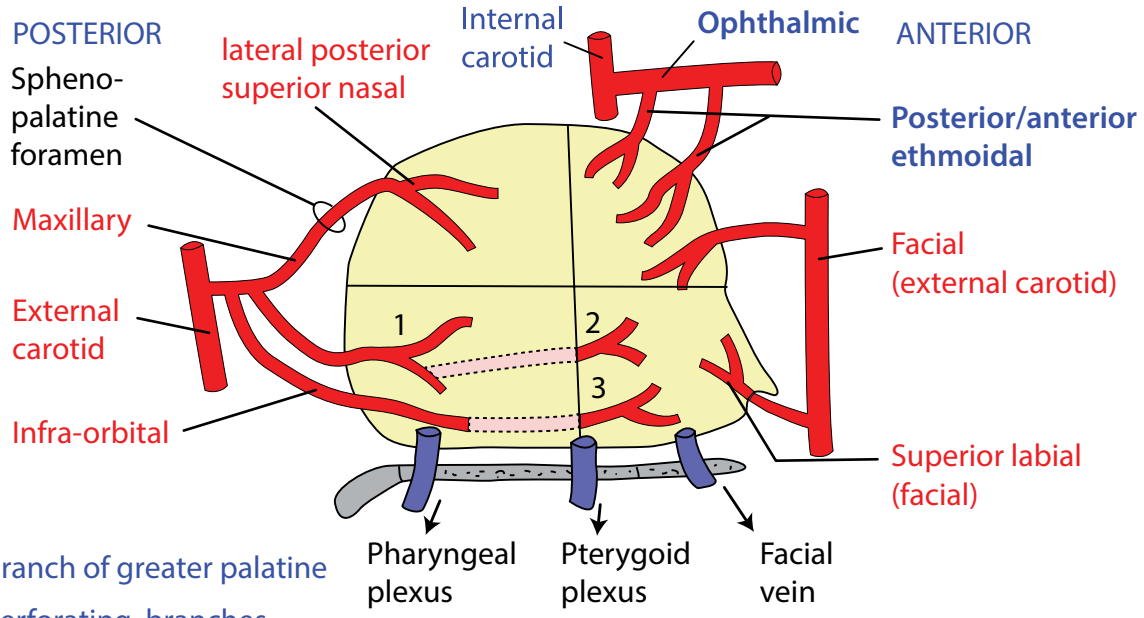


Venous drainage
Anterior - to face
Posterior - to pterygoid plexus. Also via ethmoidal veins to ophthalmic and inferior cerebral veins. 1% via foramen caecum to superior sagittal sinus

Lymphatic drainage of lateral wall and septum
Posterior: To retropharyngeal and to anterior/ superior deep cervical nodes. **Anterior:** To submandibular nodes

Lining
Respiratory epithelium - pseudostratified ciliated columnar with mucous cells and very vascular
Olfactory epithelium - ciliated nerve cells, yellowish, on roof and septum, under superior concha and in spheno-ethmoidal recess

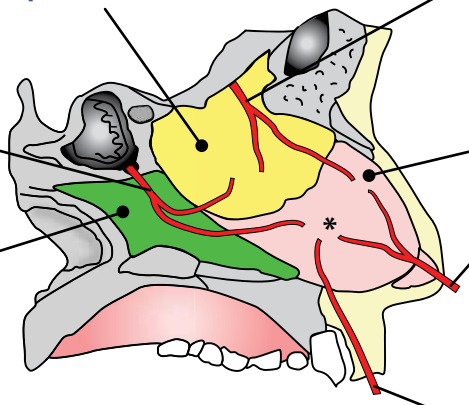
BLOOD SUPPLY OF LATERAL WALL OF NOSE



1. Branch of greater palatine
2. Perforating branches of greater palatine
3. Anterior superior alveolar from infra-orbital

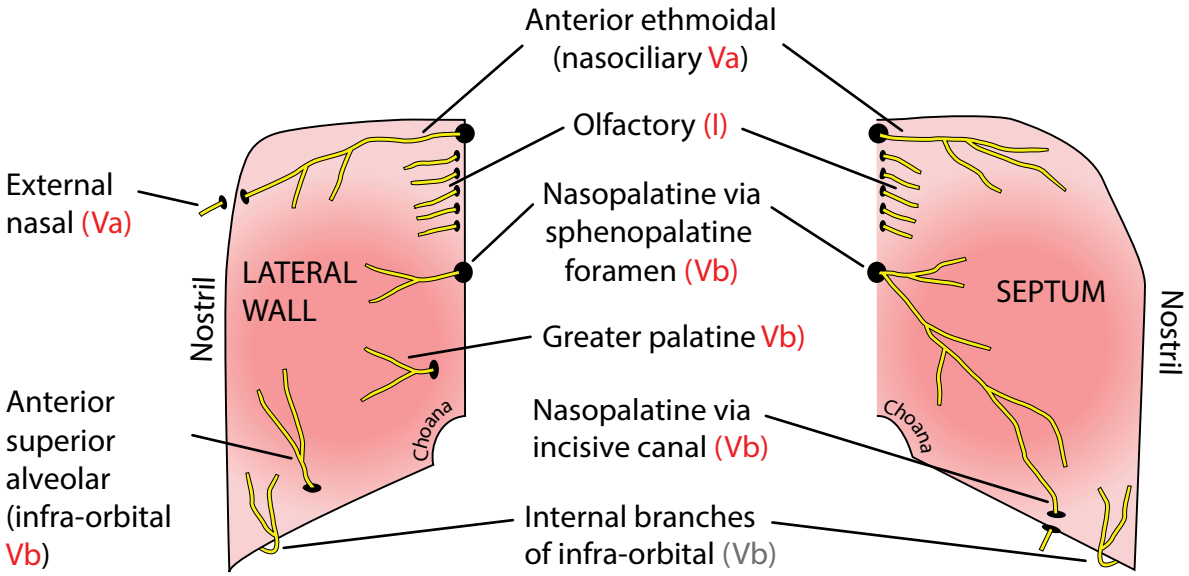
Note: Anastomoses between internal and external carotid arteries on both medial and lateral walls of the nasal cavity

NASAL SEPTUM AND LITTLE'S AREA
(A common site for nose bleeds)



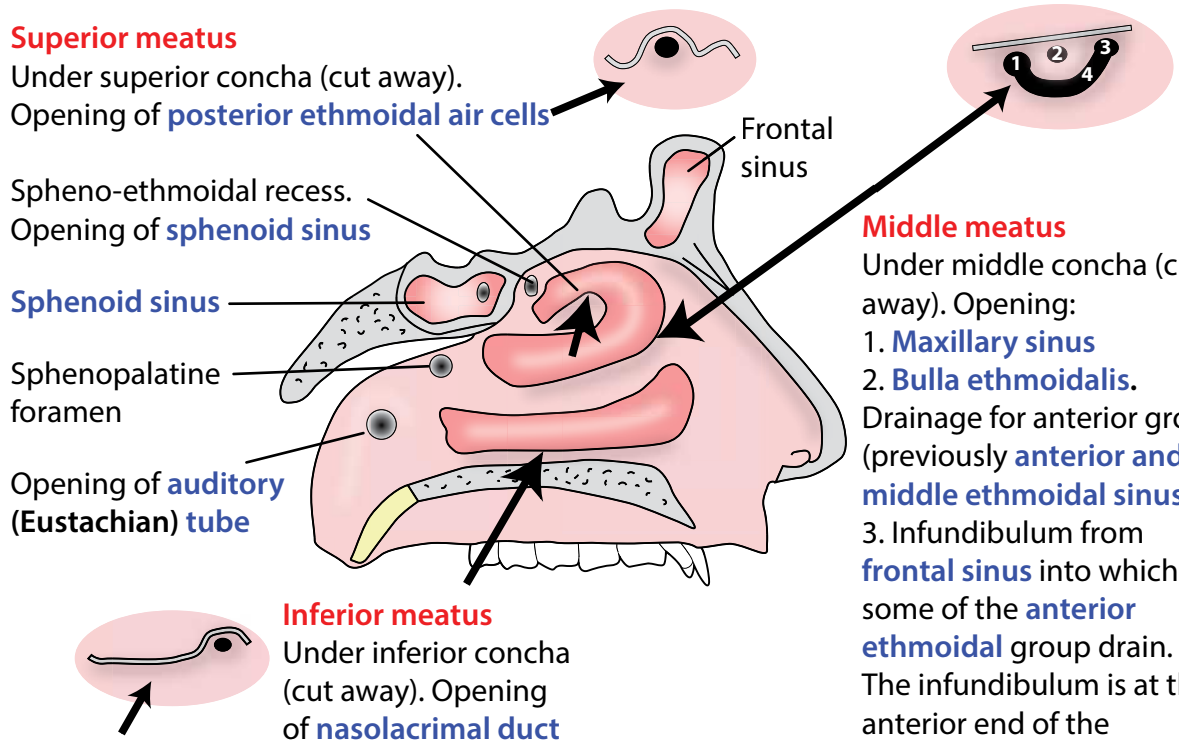
Note anastomoses between internal and external carotid arteries on both medial and lateral walls of the nasal cavity. Hence damaged arteries bleed from both severed ends

NERVE SUPPLY OF RIGHT NASAL CAVITY



Roof: Olfactory (I) and anterior ethmoidal (Va)
Middle: Branches of Vb
Floor: Alveolar, infra-orbital and nasopalatine (Vb)
All branches of Vb are via pter

LATERAL WALL OF LEFT NASAL CAVITY



Superior meatus
Under superior concha (cut away).
Opening of **posterior ethmoidal air cells**

Spheno-ethmoidal recess.
Opening of **sphenoid sinus**

Sphenoid sinus

Sphenopalatine foramen

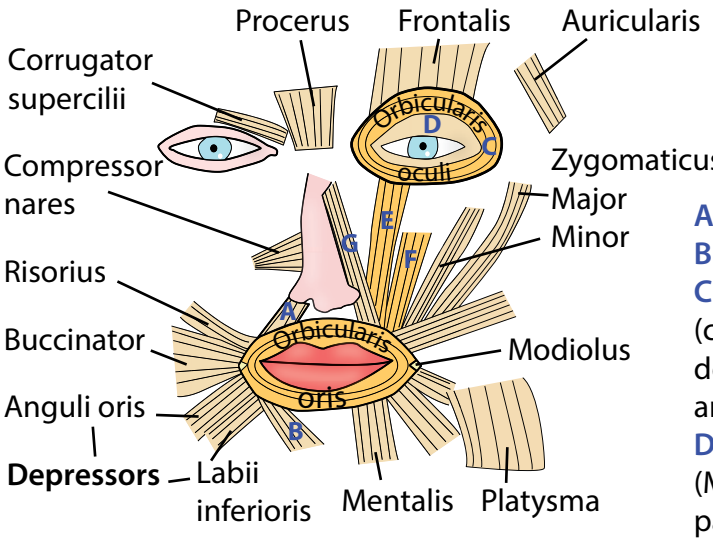
Opening of **auditory (Eustachian) tube**

Frontal sinus

Middle meatus
Under middle concha (cut away). Opening:
1. **Maxillary sinus**
2. **Bulla ethmoidalis.**
Drainage for anterior group (previously **anterior and middle ethmoidal sinus**)
3. Infundibulum from **frontal sinus** into which some of the **anterior ethmoidal** group drain. The infundibulum is at the anterior end of the
4. **Hiatus semilunaris**

Inferior meatus
Under inferior concha (cut away). Opening of **nasolacrimal duct**

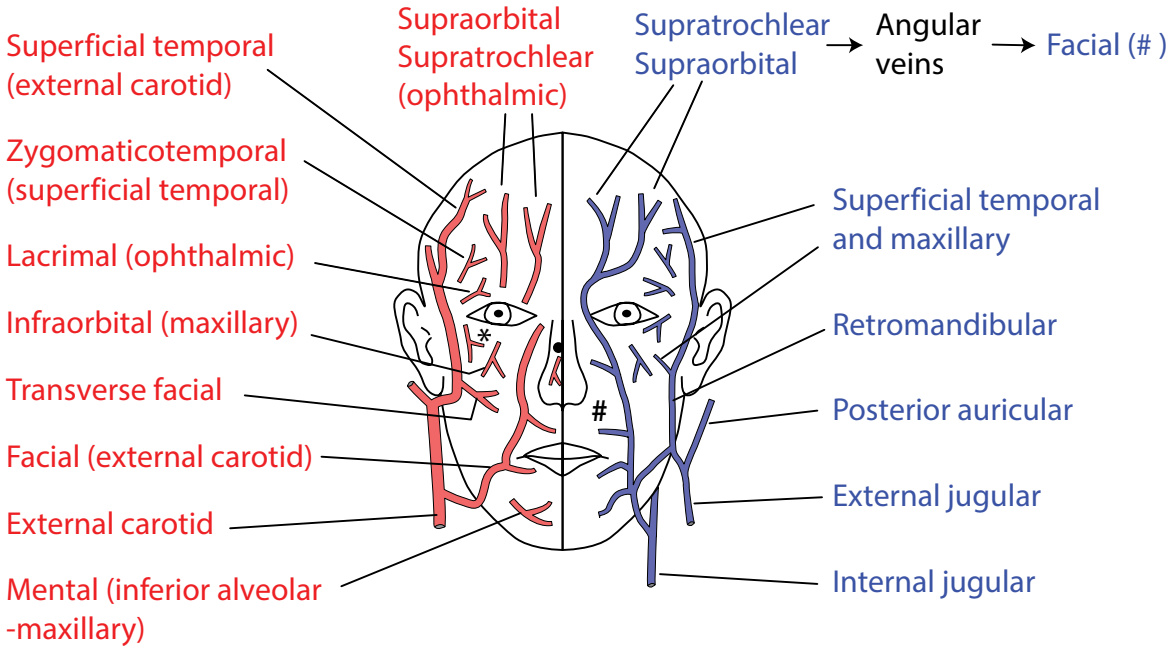
MUSCLES OF FACIAL EXPRESSION



Note: The face has no deep fascia, variable amount of fat, good blood supply and drainage. Muscles are 2nd arch mesoderm, equivalent to the panniculus carnosus of animals, often attached to the dermis and are arranged into sphincters, dilators and expressors

A: Incisive slip of orbicularis oris
B: Mental slip of orbicularis oris
C: Orbital part of orbicularis oculi (complete sphincter, screws up eye, decreases volume of conjunctiveal sac and tears spill over)
D: Palpebral part of orbicularis oculi (Medial palpebral ligament to lateral palpebral raphe. Keeps volume of conjuctival sac constant, no tear spill, closes eye)
E: Levator labii superioris
F: Levator anguli oris
G: Levator labii superioris alaeque nasi (Dilator nares and depressor septi are not shown)

FACE: ARTERIAL SUPPLY AND VENOUS DRAINAGE

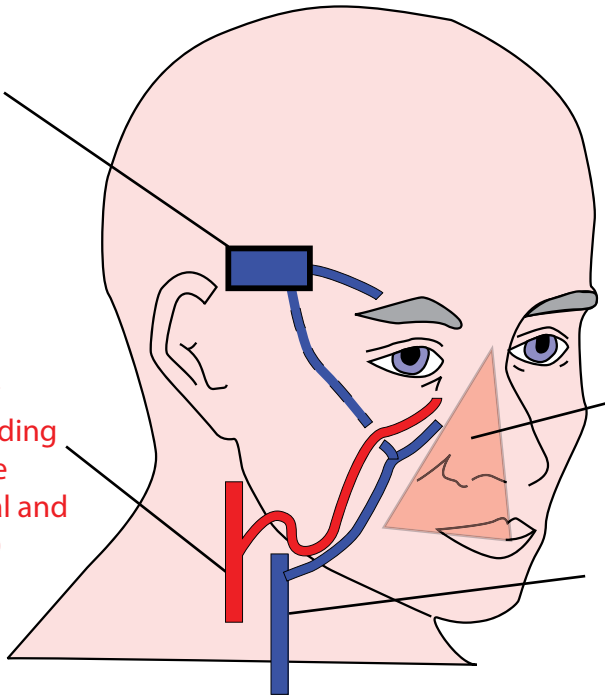


* Zygomaticofacial (superficial temporal)

• = External nose: Lateral nasal (facial) and external nasal (anterior ethmoidal - ophthalmic)

VESSELS ON FACE - VENOUS ANASTOMOSES

DANGER! Valveless venous connections from face and orbit to cavernous sinus. Risk of spread of infection to give cavernous sinus thrombosis

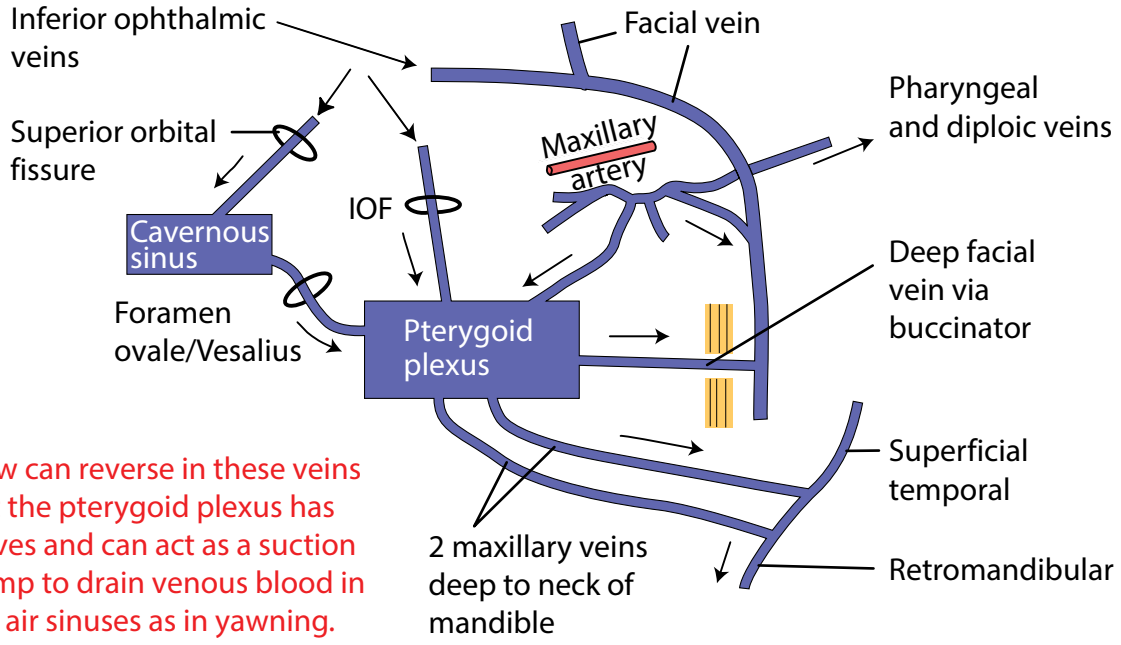


DANGER AREA!!

External carotid artery giving facial artery, ending at inner canthus of eye (superior, inferior labial and lateral nasal branches)

Facial vein draining into internal jugular vein

PTERYGOID PLEXUS CONNECTIONS - DIAGRAMMATIC ONLY

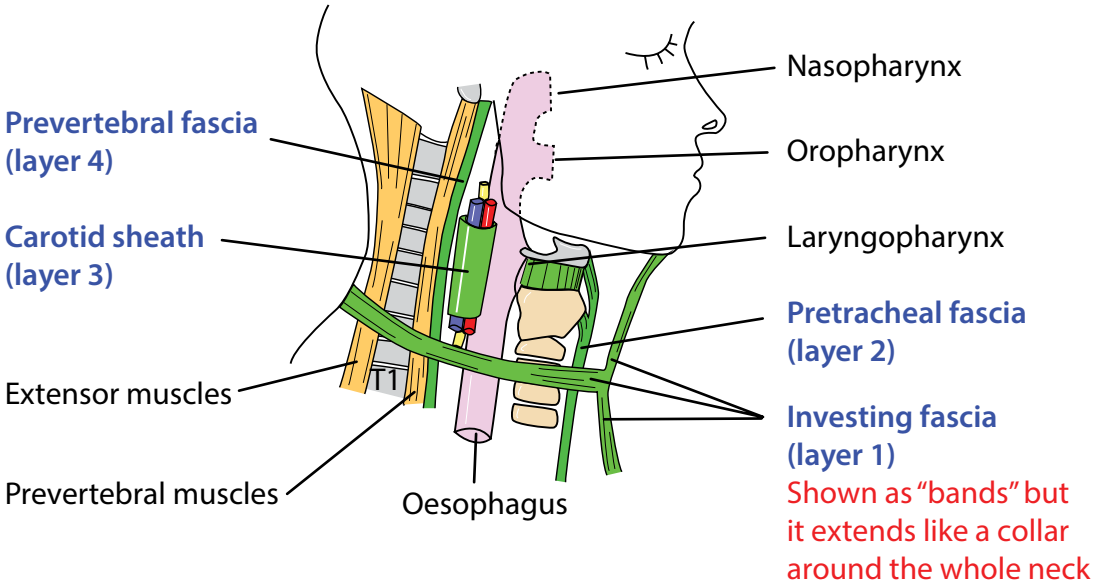


Flow can reverse in these veins but the pterygoid plexus has valves and can act as a suction pump to drain venous blood in the air sinuses as in yawning. Danger for infection between angular and deep facial veins

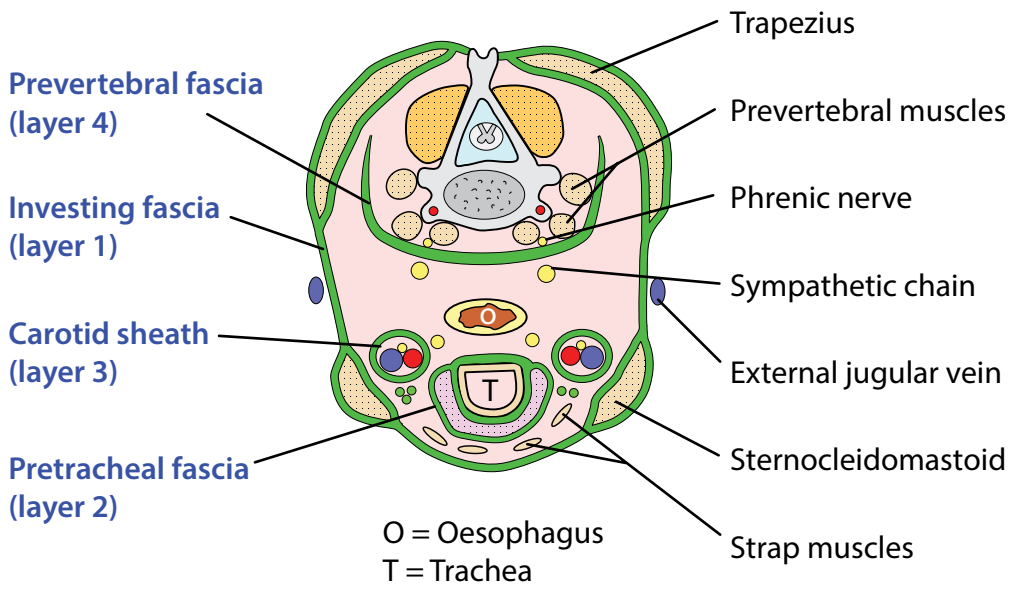
IOF: Inferior orbital fissure

5.14 Neck Fascia, Vessels and General Anatomy

DEEP FASCIA OF NECK - lateral view

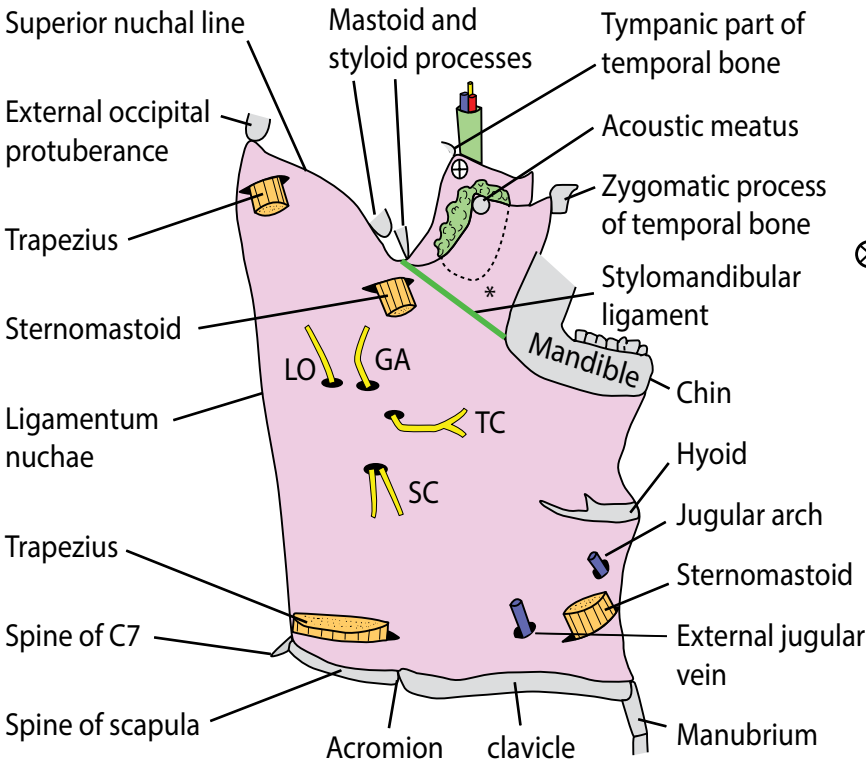


DEEP FASCIA OF NECK - Axial section



Layers of deep fascia separate tissues and give closed areas that are liable to localised infection such as Ludwig's Angina

INVESTING LAYER OF DEEP FASCIA OF NECK

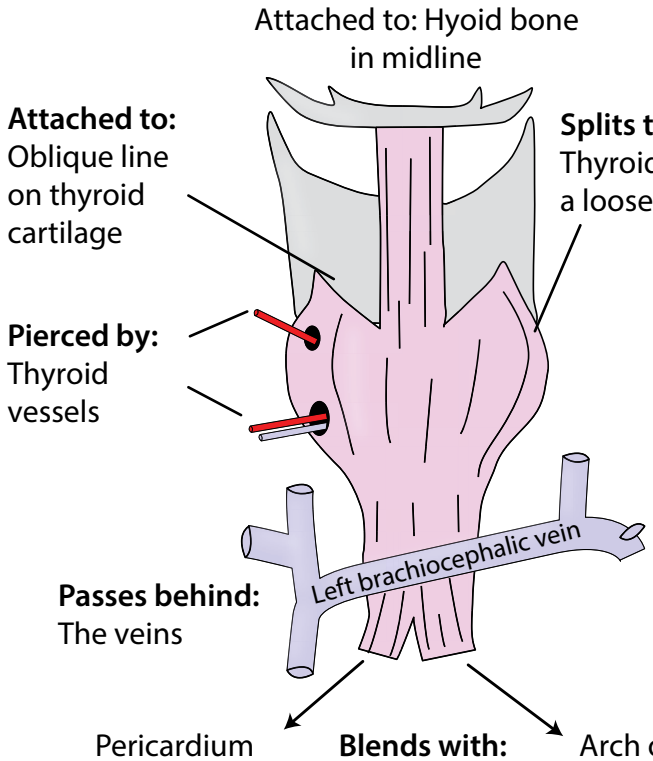


* Anterior layer of parotid fascia is the superficial layer of the investing fascia that has split from the stylomandibular ligament

⊗ Posterior layer of parotid fascia is the deep layer of the investing fascia that has split from the stylomandibular ligament. It fuses with the parotid gland

LO: Lesser occipital
GA: Great auricular
TC: Transverse cervical
SC: Supraclavicular

PRETRACHEAL PART OF DEEP FASCIA OF NECK



Fuses with:
Carotid sheath and investing fascia behind sternomastoid

Limited above by:
Attachments of sternohyoid and sternothyroid

It is deep to:
Sternothyroid
Sternohyoid
Omohyoid

It slides on:
Prevertebral fascia

PREVERTEBRAL PART OF DEEP FASCIA OF NECK

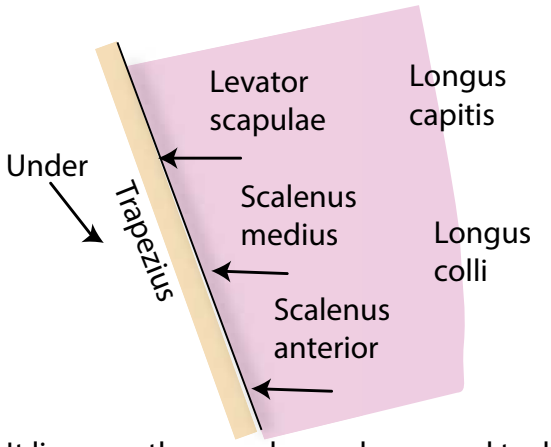
Lateral

Medial

From: base of skull

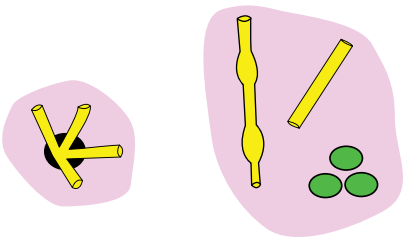
Extends

To: body of T3



It blends with the anterior longitudinal ligament. Its lower border laterally is the lower border of scalenus anterior

It lies over the muscles as shown and tucks under the anterior edge of trapezius laterally



Pierced by these nerves: Great auricular, lesser occipital, transverse cervical, supraclavicular, inferior root of ansa cervicalis
Lying on it: Sympathetic chain, lymph nodes, spinal root of accessory nerve
Deep to it: Cervical plexus, trunks of brachial plexus, 3rd part of subclavian artery, phrenic nerve

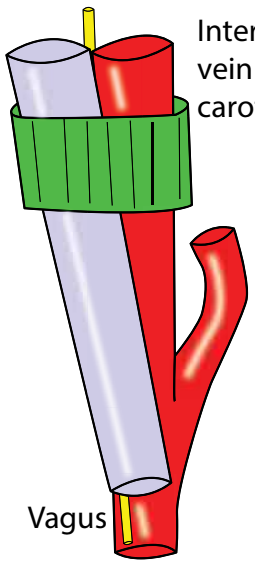
CAROTID SHEATH (Right side)

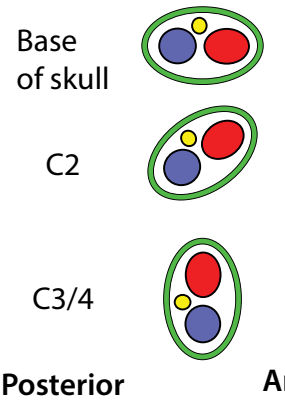
Anterior view

From base of skull (petrous and tympanic parts of temporal bones, blending with deep layer of parotid fascia)

Adventitia of aortic arch

Sheath is thinnest over vein





- **Fuses with:** Pretracheal fascia and investing fascia deep to sternocleidomastoid
- **Ansa cervicalis:** Is anterior to carotid sheath
- **Escaping from upper sheath are:** Glossopharyngeal (IX), superior laryngeal (X), spinal root of accessory (XI) and hypoglossal (XII) nerves

TISSUE SPACES IN THE NECK

PREVERTEBRAL SPACE
Closed space behind prevertebral fascia which allows infection to track down into axilla via the axillary sheath which is, itself, part of the prevertebral fascia which has been dragged off by the subclavian artery as it emerges from behind scalenus anterior

RETROPHARYNGEAL SPACE
Immediately anterior to prevertebral fascia. Below, it extends behind oesophagus to diaphragm via superior and then posterior mediastinum. Infection may spread from here, laterally, behind the carotid sheath into the posterior triangle

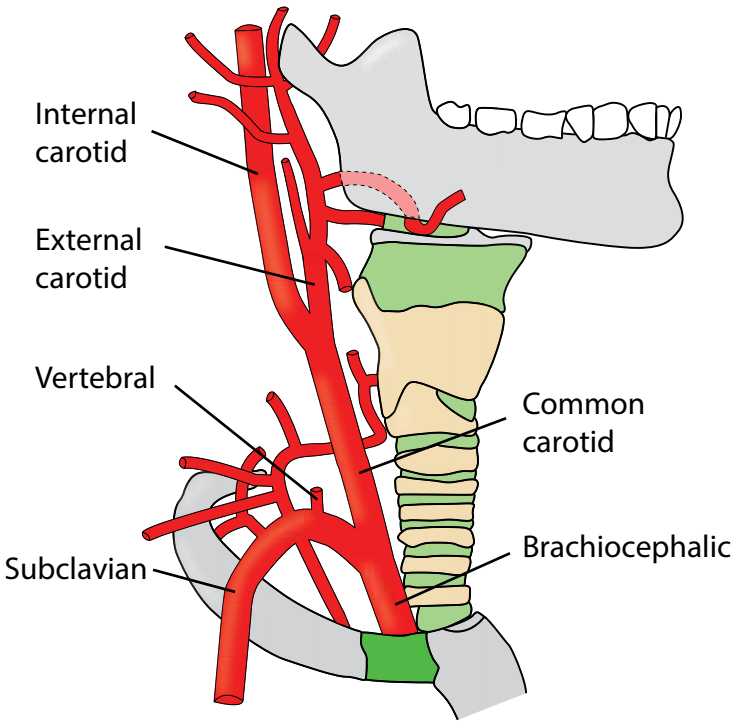
PARAPHARYNGEAL SPACE
Lateral continuation of retropharyngeal space

SUBMANDIBULAR SPACE
Extends superiorly to the investing layer of deep cervical fascia, between hyoid and mandible to mucous membrane of floor of mouth. Contains mylohyoid muscle, sublingual gland superior to this muscle and submandibular gland hooking around its posterior border. Infection here gives cellulitis known as **LUDWIG'S ANGINA**

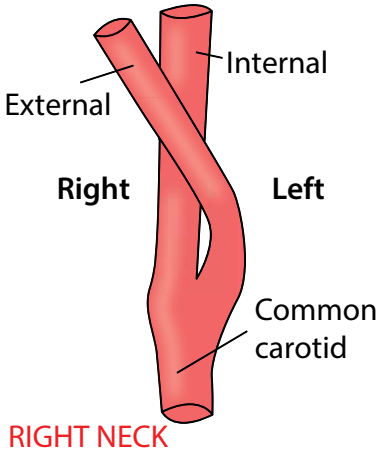
INTERNAL AND EXTERNAL CAROTID ARTERIES AND BIFURCATION

External carotid branches:
1. Ascending pharyneal
2. Superior thyroid
3. Lingual
4. Facial
5. Occipital
6. Posterior auricular
7. Superficial temporal
8. Maxillary

The bifurcation is at the level of C4 - upper thyroid cartilage



RIGHT CAROTID ARTERY BIFURCATION

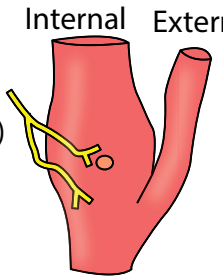


RIGHT NECK

Note that the external carotid is initially anteromedial as it leaves the common carotid

The carotid body lies at the bifurcation of the common carotid artery. It measures the pH of the blood. Tumours are pulsatile and appear just anterior to sternomastoid
Nerve: IX and (X)

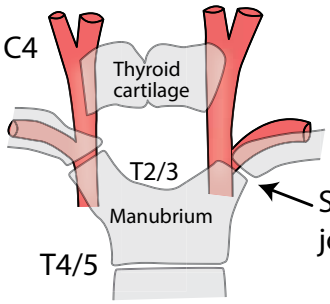
Mostly glossopharyngeal (IX) with small contribution from vagus (X)



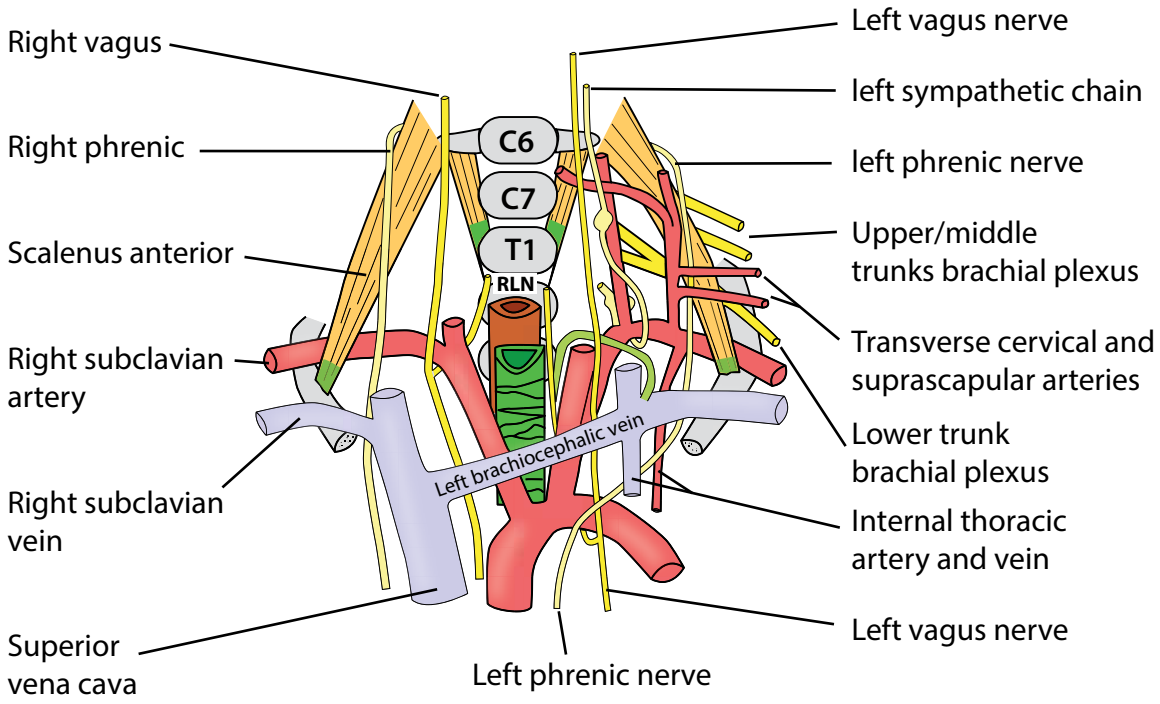
Carotid sinus (Baroreceptor)

Carotid body (Chemoreceptor)

Surface marking for carotid bifurcation (C4) is upper thyroid cartilage

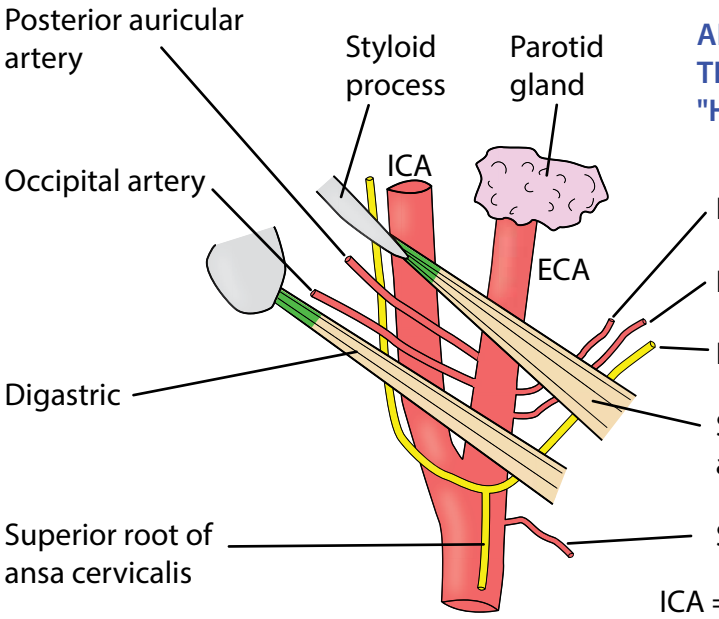


RELATIONS TO SCALENUS ANTERIOR



RLN: Recurrent laryngeal nerves

RELATIONS OF THE BIFURCATION OF THE CAROTID ARTERIES 1



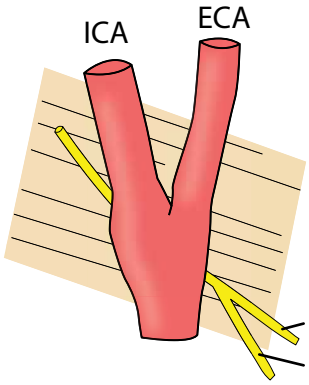
ANTERIOR TO ARTERIES THE STRUCTURES ARE "HYOID" RELATED

ICA = Internal carotid artery

ECA = External carotid artery

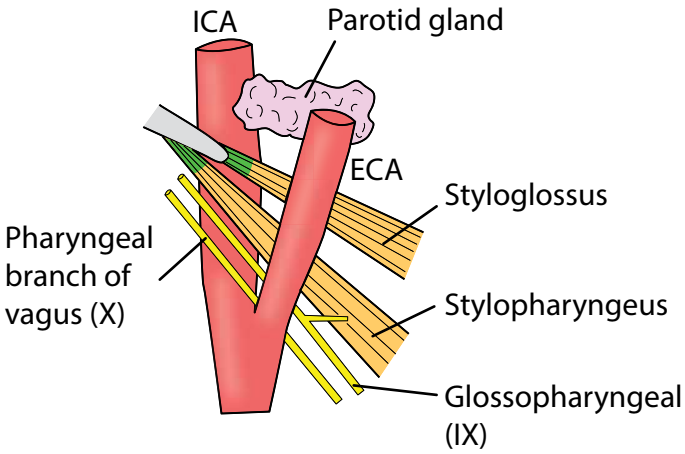
RELATIONS OF THE BIFURCATION OF THE CAROTID ARTERIES 2

POSTERIOR TO ARTERIES THE STRUCTURES ARE "LARYNX" RELATED



Branches of superior laryngeal branch of vagus

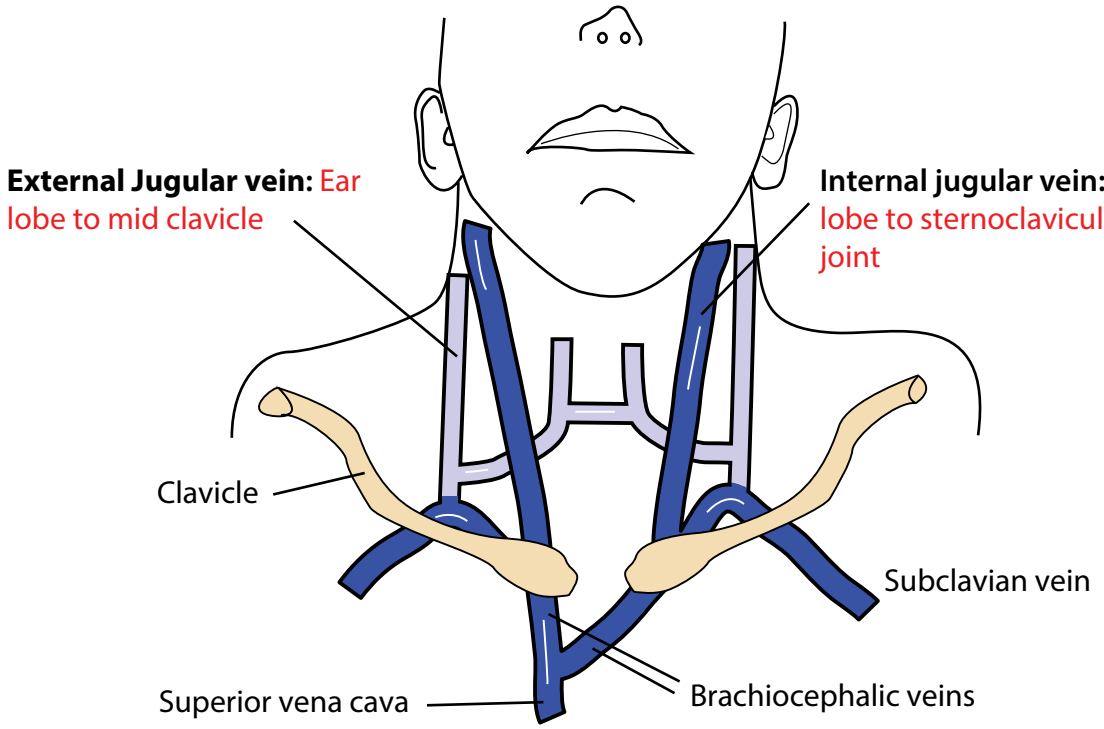
BETWEEN ARTERIES THE STRUCTURES ARE TONGUE/PHARYNX" RELATED



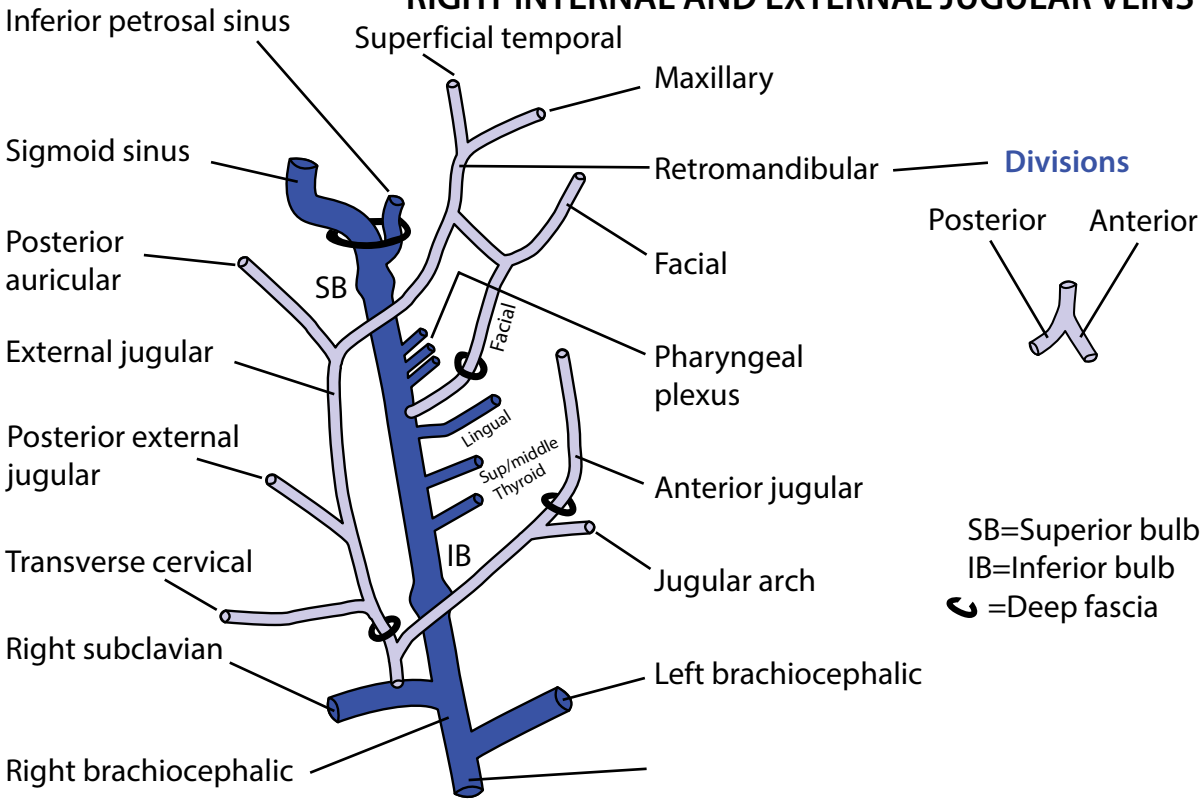
ICA = Internal carotid artery

ECA = External carotid artery

SURFACE ANATOMY OF JUGULAR VEINS

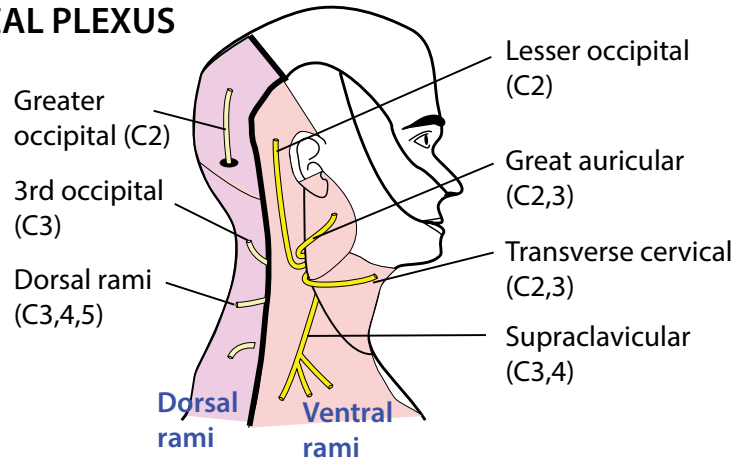


RIGHT INTERNAL AND EXTERNAL JUGULAR VEINS



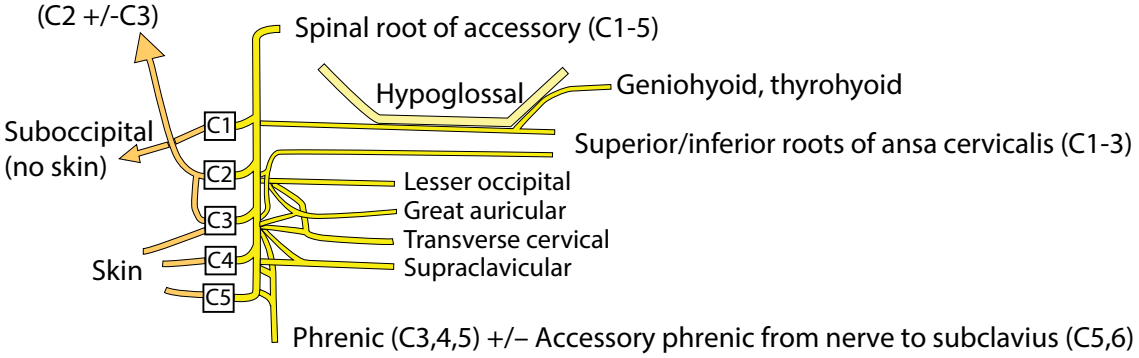
CERVICAL PLEXUS

Great auricular nerve should not be confused with:
Posterior auricular branch of facial (VII)-(motor to occipitalis)
OR
Auriculotemporal branch of mandibular (Vc) (sensory to hairy temple)

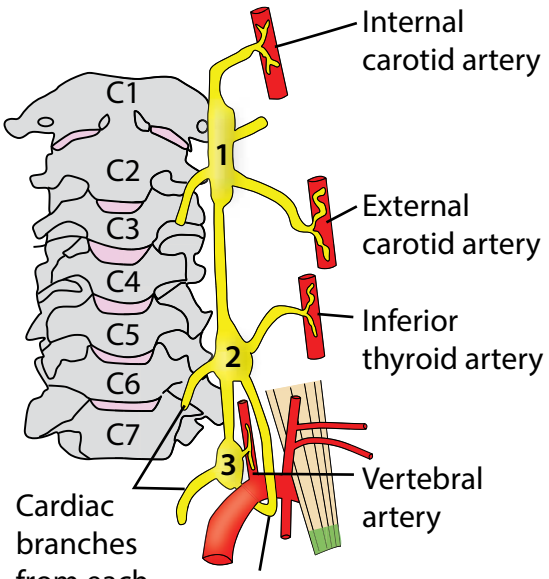


Posterior rami | **Anterior rami**

Greater occipital (C2 +/-C3)



SYMPATHETIC CHAIN AND GANGLIA IN NECK

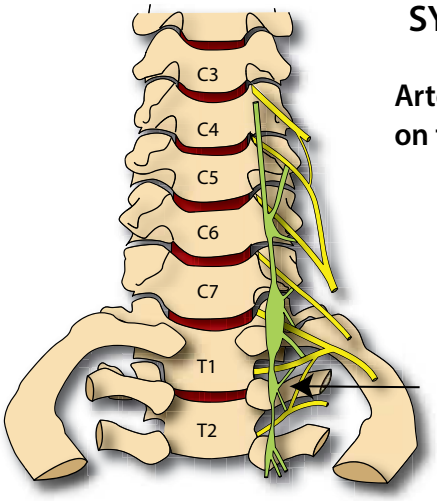


1. SUPERIOR CERVICAL GANGLION
Anterior to lateral mass C1 and C2. 3cm long. 4 somatic branches. (C1-4). Branches to internal and external carotid arts

2. MIDDLE CERVICAL GANGLION
At C6, medial to carotid tubercle. Anterior to vertebral artery. 2 somatic branches. (C5,6). Branches to inferior thyroid and subclavian arteries

3. INFERIOR CERVICAL GANGLION
At C7, behind vertebral artery. 1cm x 0.5cm on neck of 1st rib. 2 somatic branches. (C7,8). Branches to vertebral artery

SYMPATHETIC CHAIN IN LOWER NECK



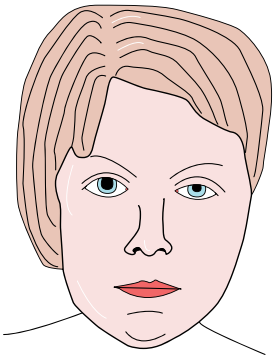
Arterial spasm may result from irritation of sympathetics on the subclavian artery from a cervical rib

SYMPATHECTOMY

Treatment of Raynaud's phenomenon by cutting the preganglionic sympathetic fibres at T2 and T3 to increase the blood flow to the fingers by preventing vasoconstriction

Small pupil
Mild ptosis
Flushed face
Dry face
Apparent enophthalmos

LEFT HORNER'S SYNDROME



LYMPH NODES IN THE HEAD AND NECK

PRE-AURICULAR
Forehead, temple, orbit, cheek

SUPERFICIAL CHAIN (superficial tissues)

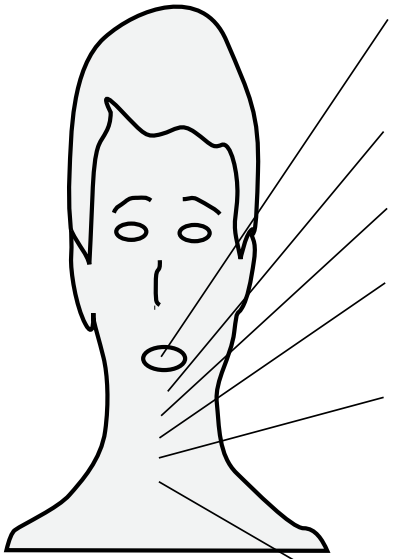
JUGULAR LYMPH TRUNK

SUBMANDIBULAR
Forehead, frontal and maxillary sinuses, anterior nose, upper lip, lower face, tongue and floor of mouth

SUBMENTAL
Chin, tip of tongue. Tip of tongue and posterior 1/3 drain bilaterally. There is also overlap across the midline in the anterior 2/3

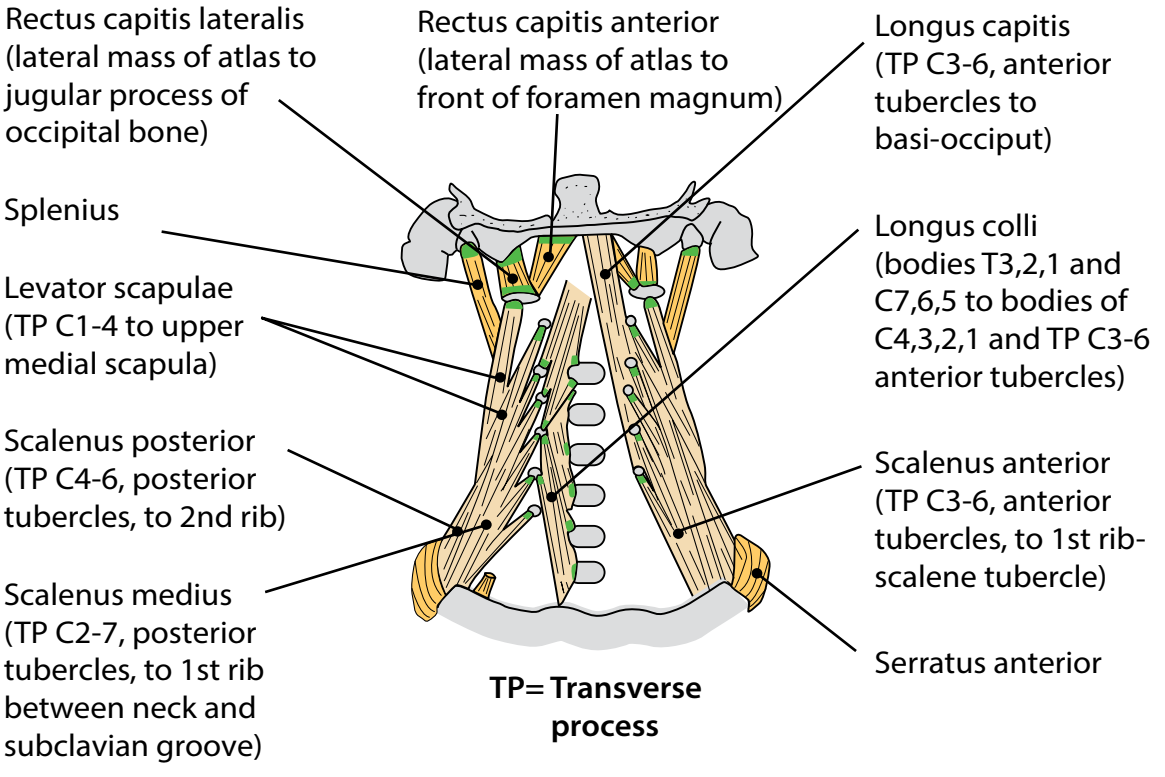
DEEP CERVICAL CHAIN (Deeper tissues -thyroid, larynx, tonsil, etc)
Jugulodigastric (upper group): Between sternomastoid, angle of jaw and posterior digastric)
Jugulo-omohyoid (lower group): Above inferior belly of omohyoid, behind jugular vein, under posterior border of sternomastoid

VERTEBRAL LEVELS OF STRUCTURES



C1	Open mouth, dens, spinal root of XI crosses transverse process of atlas
C2	Superior cervical ganglion
C3	Body of hyoid bone
C4	Upper thyroid cartilage, bifurcation of common carotid artery
C6	Cricoid cartilage, larynx becomes trachea, pharynx becomes oesophagus, vertebral artery enters foramen transversarium, middle cervical ganglion, carotid tubercle of Chassaignac; inferior thyroid artery crosses medially to reach thyroid
C7	First easily palpable spinous process, stellate ganglion

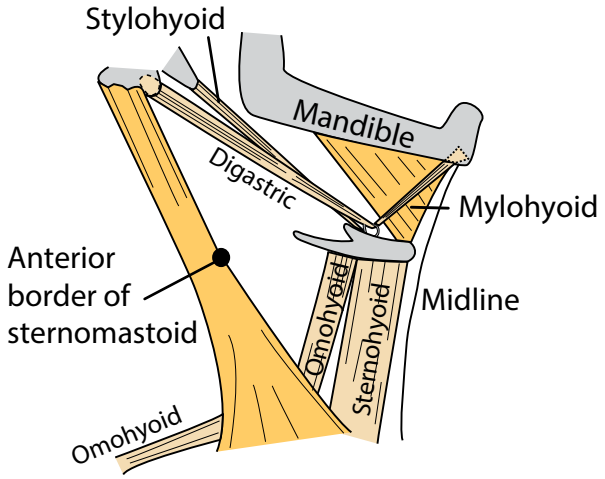
PREVERTEBRAL MUSCLES

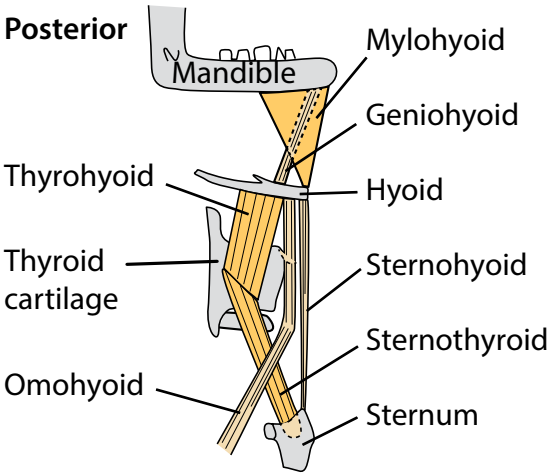


TP= Transverse process

5.15 Neck Triangles, Muscles, Thyroid and Parathyroid Glands

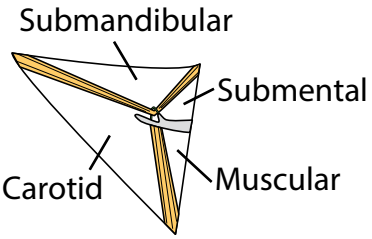
ANTERIOR TRIANGLE OF NECK
SUPRAHYOID AND STRAP MUSCLES





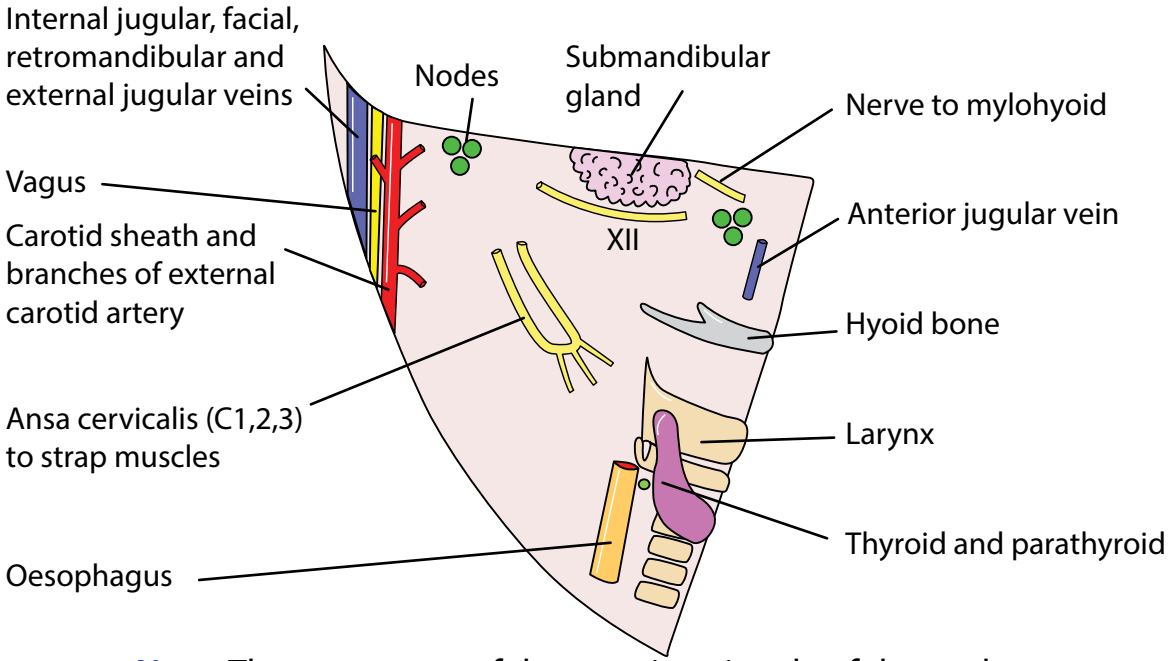
MUSCLES
Lie between pretracheal and investing fasciae. Supplied by anterior rami of C1-3, ansa cervicalis, facial nerve and nerve to mylohyoid (Vc)

Anterior triangle of neck is bordered by mandible, midline and anterior border of sternomastoid



SUB-TRIANGLES

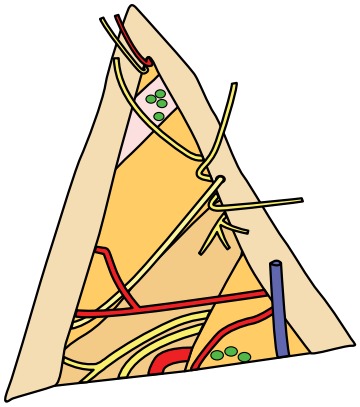
RIGHT ANTERIOR TRIANGLE OF NECK
DIAGRAM OF CONTENTS



Note: These contents of the anterior triangle of the neck are

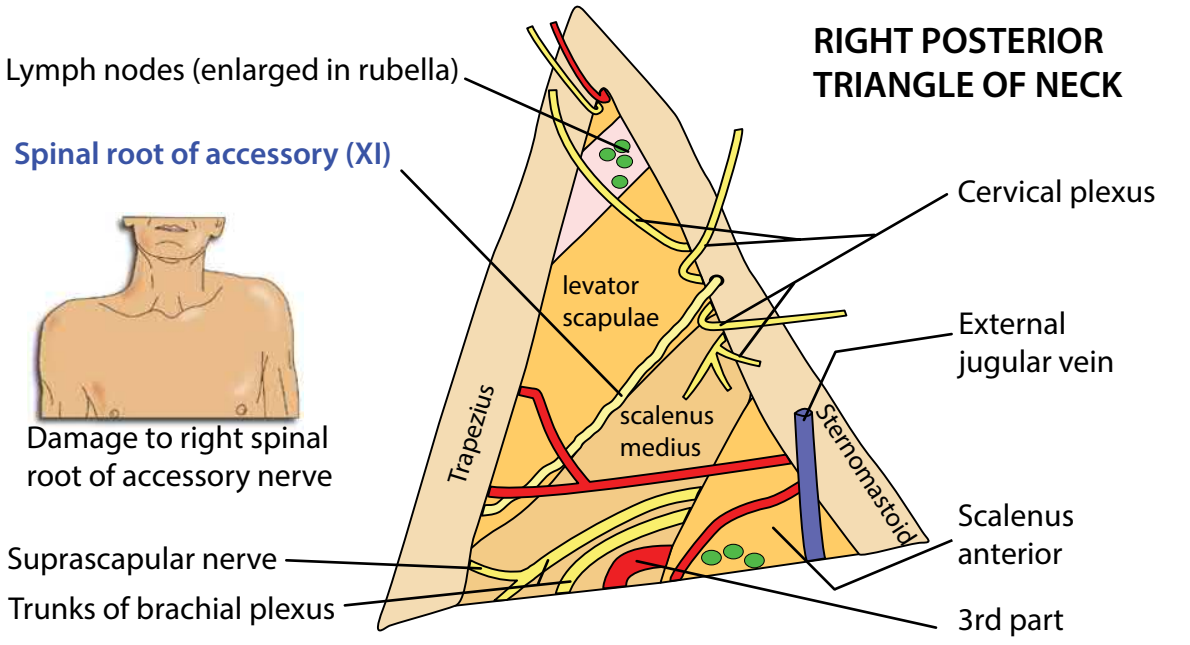
POSTERIOR TRIANGLE OF NECK

Boundaries: Posterior border of sternocleidomastoid, anterior border of trapezius, middle 1/3 clavicle.
Shape: Spiral.
Roof: Investing fascia, platysma, external jugular vein.
Floor: Prevertebral fascia covering muscles, subclavian artery, trunks of brachial plexus and cervical plexus.
Contents:
Arteries: Occipital, superficial cervical, suprascpular.
Veins: Transverse cervical, suprascapular, external jugular.
Nerves: Branches of cervical plexus, spinal root of accessory.
Muscles: Omohyoid with its sling.
Lymph nodes: Occipital (rubella/scalp infections), supraclavicular (part of the deep chain)



Note: Each sternomastoid acting alone gives flexion and lateral rotation but acting together they give protrusion of head
Nerve: Spinal root of accessory (C1-5)

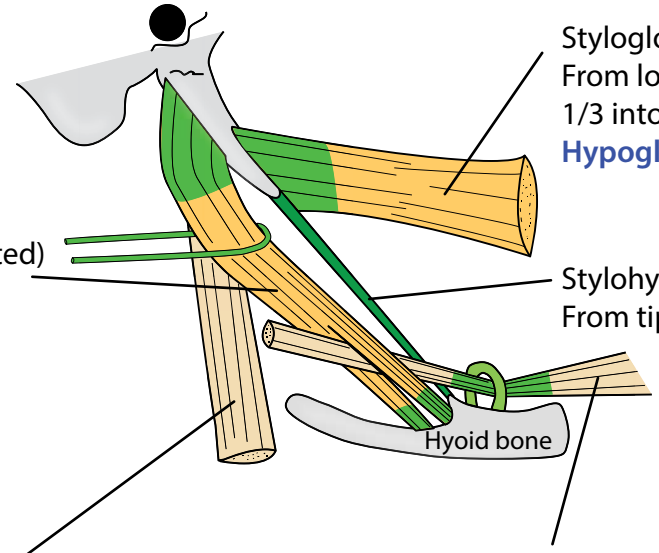
RIGHT POSTERIOR TRIANGLE OF NECK



Surface anatomy of spinal root of XI in posterior triangle:
1. Earlobe to 5cm up trapezius. OR
2. 1/3 down posterior border of sternocleidomastoid to 1/3 up anterior border of trapezius

RIGHT STYLOID PROCESS MUSCLE AND LIGAMENT ATTACHMENTS

LATERAL VIEW



Styloglossus
From lower anterior 1/3 into tongue
Hypoglossal nerve (XII)

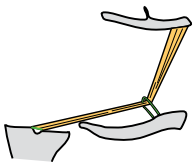
Stylohyoid (Retracted) from upper posterolateral 1/3
Facial nerve (VII)

Stylohyoid ligament
From tip to lesser cornu

Stylopharyngeus
From upper posteromedial 1/3 to posterior thyroid lamina
Glossopharyngeal nerve (IX)

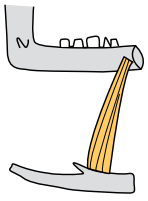
Digastric from mastoid process to inner symphysis of mandible
Anterior: Mandibular nerve (Vc)
Posterior: Facial nerve (VII)

NECK MUSCLES 1

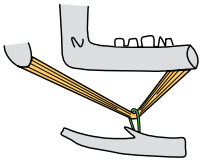


OMOHYOID
Transverse suprascapular ligament via clavicle to hyoid
Nerve: 2 branches from ansa cervicalis (C1-3)

STYLOHYOID
Posterior base of styloid process to hyoid
Nerve: Facial nerve (VII)

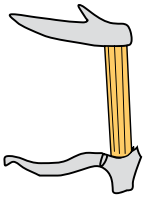


GENIOHYOID
Inferior mental (genial) spine on mandible to hyoid
Nerve: C1 fibres on hypoglossal

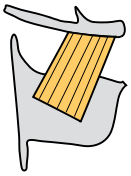


DIGASTRIC
Digastric notch on mastoid process, via sling on hyoid to digastric fossa on posterior of anterior mandible
Nerve: Anterior belly - nerve to mylohyoid (Vc)
Posterior belly - facial nerve (VII)

NECK MUSCLES 2

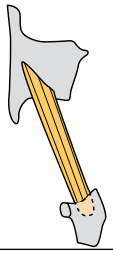


STERNOHYOID
Superior/lateral/posterior manubrium to hyoid
Nerve: Ansa cervicalis (C1-3)

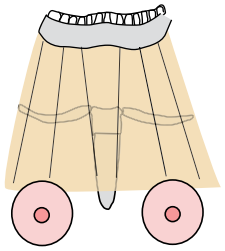


THYROHYOID
Oblique line on thyroid cartilage to hyoid
Nerve: C1 fibres on hypoglossal

MYLOHYOID
Mylohyoid line on inner mandible. 3/4 into midline raphé, rest into hyoid
Nerve: Nerve to mylohyoid (Vc)

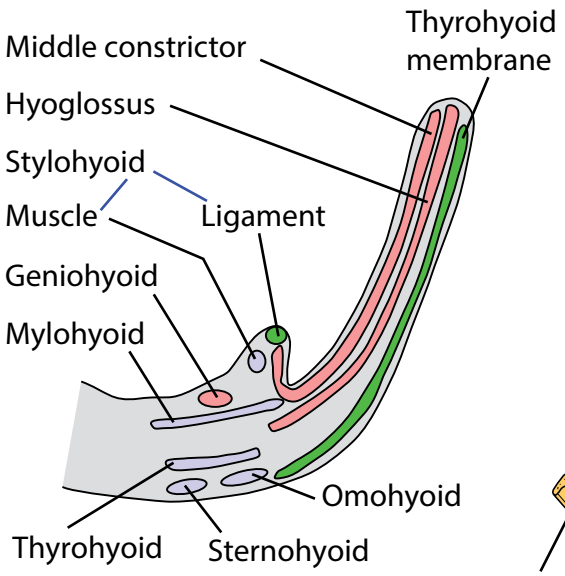


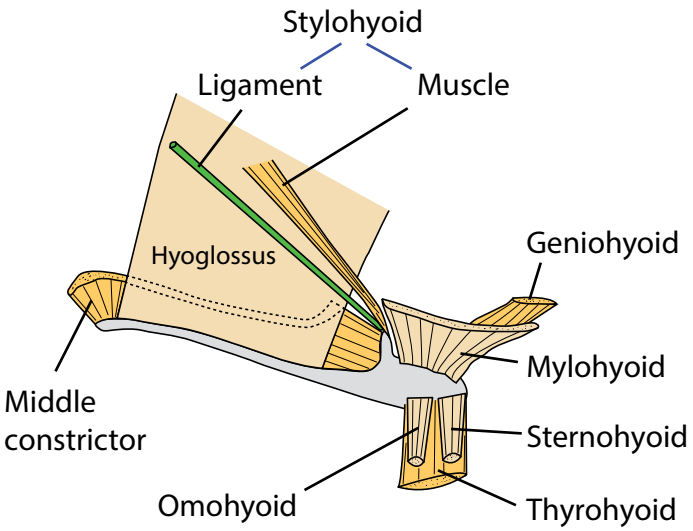
STERNOTHYROID
Posterior manubrium to oblique line on thyroid cartilage
Nerve: Ansa cervicalis (C1-3)

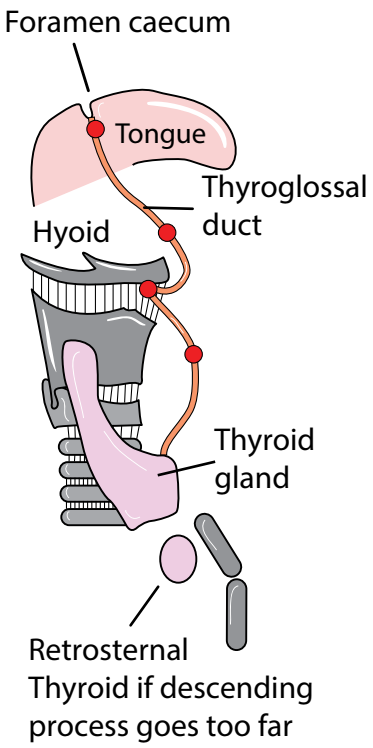


PLATYSMA
(Panniculus carnosus)
Deep fascia posterior to breasts to inferior border of mandible
Nerve: Cervical branch of facial (VII)

HYOID BONE AND ATTACHMENTS





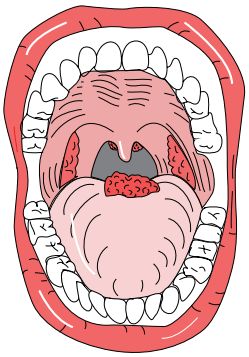


THRYOID DEVELOPMENT
THYROGLOSSAL CYST AND FISTULA

The thyroid grows down from the tongue as a bilobed diverticulum connected back to the tongue by the thyroglossal duct. This duct solidifies and then usually disappears but can leave **thyroglossal cysts, fistulae or "rests"** (ectopic bits of thyroid) on the way in the **midline**. They move on swallowing or protruding the tongue. Radioactive scans show thyroid tissue even if it is ectopically placed.

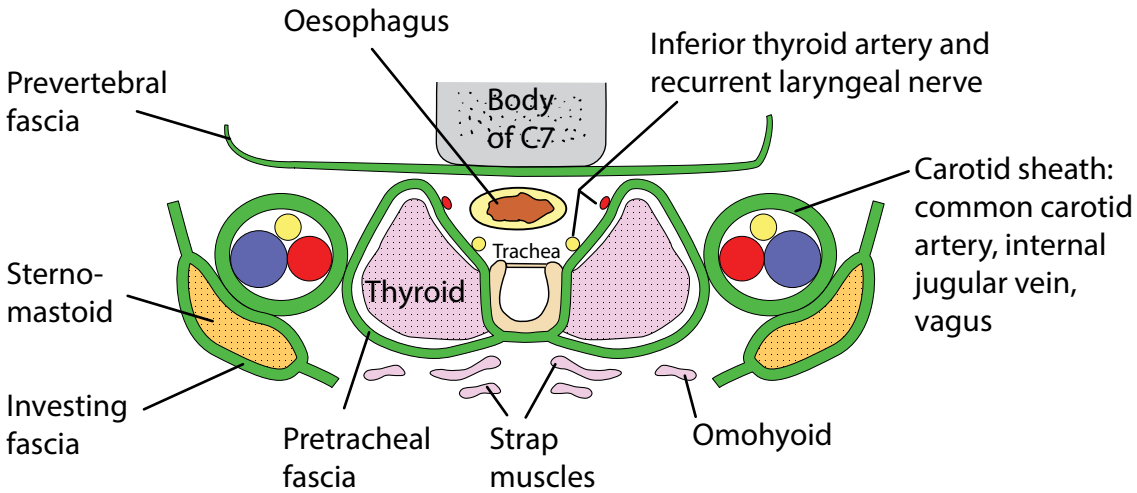
- Sites of thyroglossal cysts, remnant thyroid tissue (lingual thyroid), fistulae, sinuses and pyramidal lobe.

LINGUAL THYROID



THYROID GLAND - AXIAL SECTION AT C7

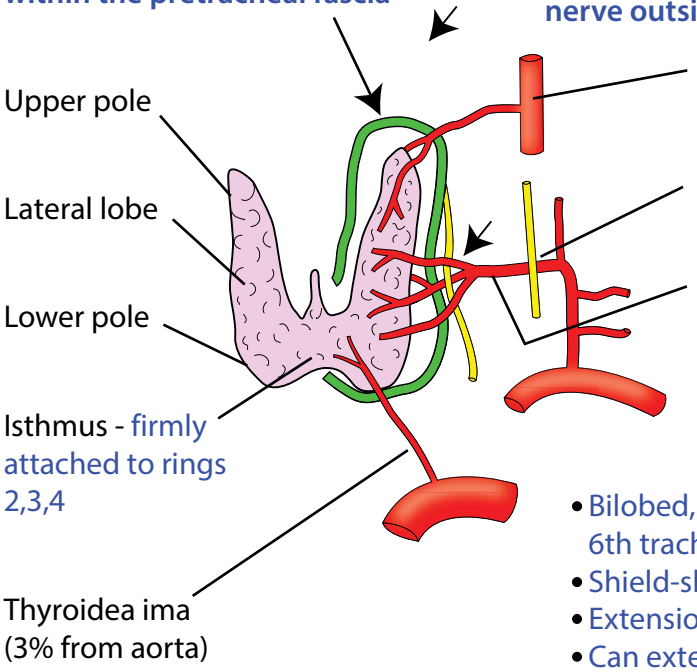
Relations of thyroid gland
Posterior: Prevertebral fascia, carotid sheath, parathyroids, trachea
Medial: Recurrent laryngeal nerve, trachea, larynx, oesophagus
Anterior: Pretracheal fascia, sternohyoid, sternothyroid, venous arch



THYROID GLAND - GENERAL AND BLOOD SUPPPLY

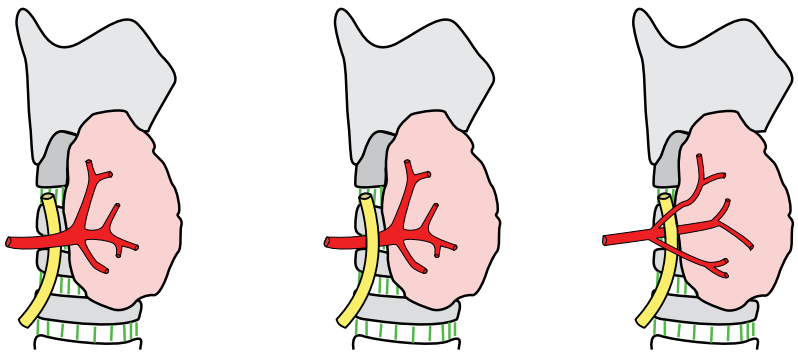
Note branching of arteries within the pretracheal fascia

Note intimate relationship of branches of inferior thyroid artery to recurrent laryngeal nerve outside the pretracheal fascia



- Bilobed, lobulated, 5cm long, extending to 6th tracheal ring
- Shield-shaped, lying on carotid sheath
- Extension upwards limited by sternothyroid
- Can extend inferiorly into mediastinum

VARIATIONS IN RELATIONSHIPS OF RECURRENT LARYNGEAL NERVE TO INFERIOR THYROID ARTERY



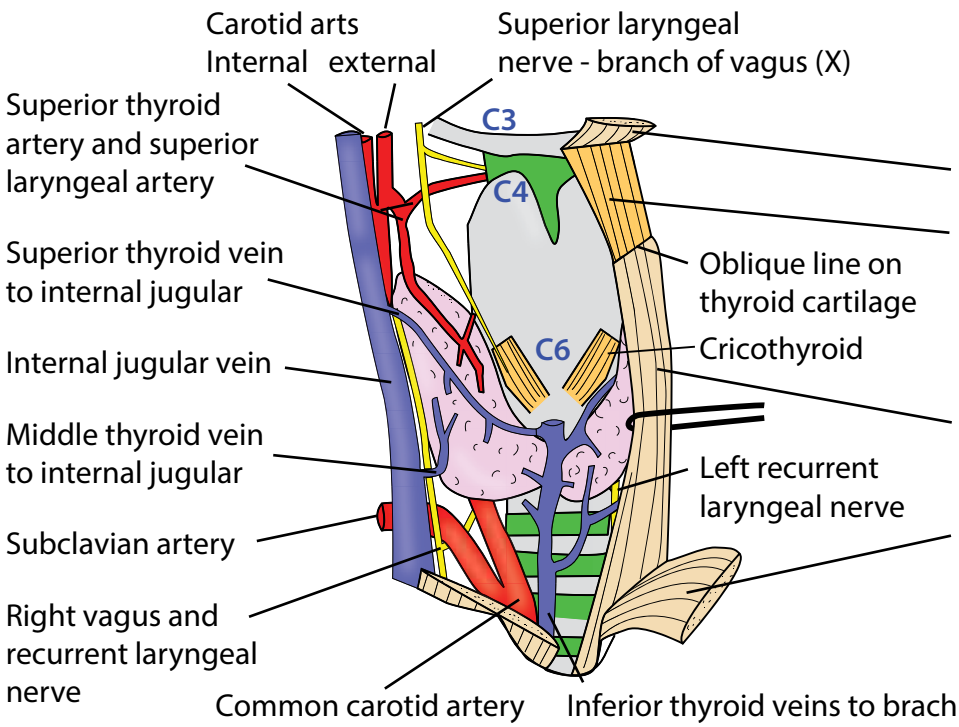
Deep to artery | Superficial to artery | In amongst artery

Risks of surgery

- To parathyroid glands
- To recurrent laryngeal nerve when ligating inferior thyroid artery and to external branch of superior laryngeal nerve (cricothyroid muscle) when ligating superior thyroid artery

Note: The right recurrent laryngeal nerve can enter larynx directly from the vagus and not pass around subclavian artery

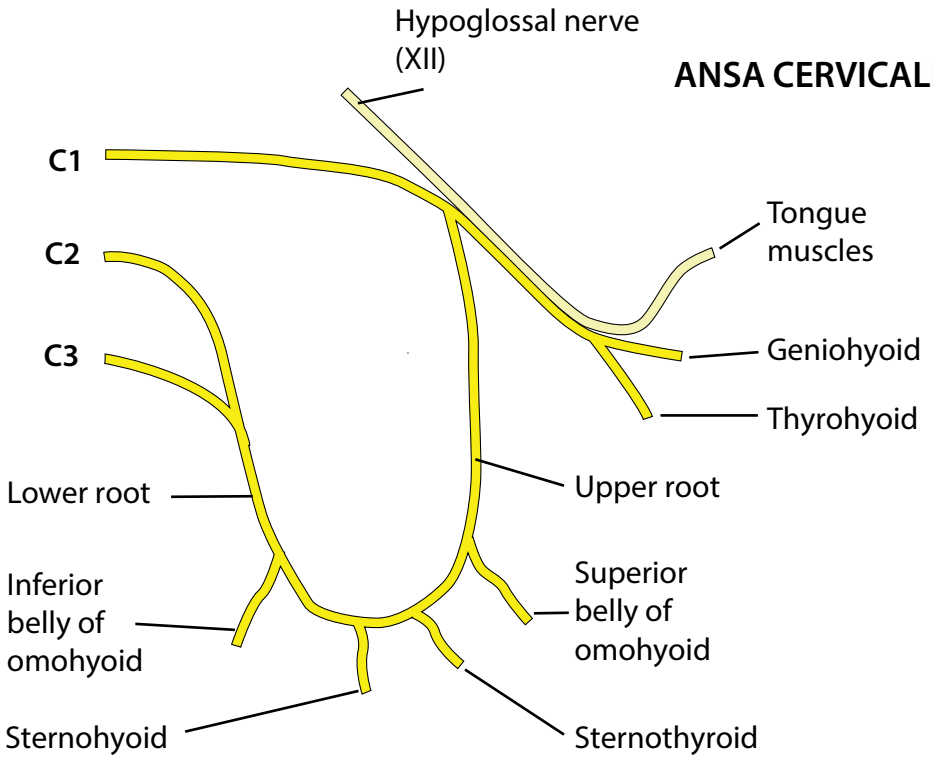
THYROID GLAND AND STRAP MUSCLES



STRAP MUSCLES
(All supplied by ansa cervicalis - C1,2,3 except thyrohyoid)

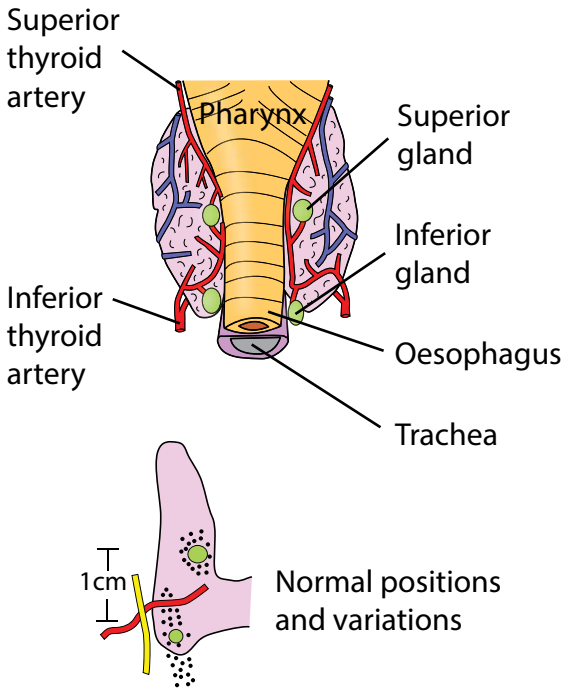
- Sternohyoid
- Thyrohyoid (C1 fibres carried on hypoglossal nerve)
- Sternothyroid
- Sternohyoid + Omohyoid not shown

ANSA CERVICALIS



PARATHYROID GLANDS

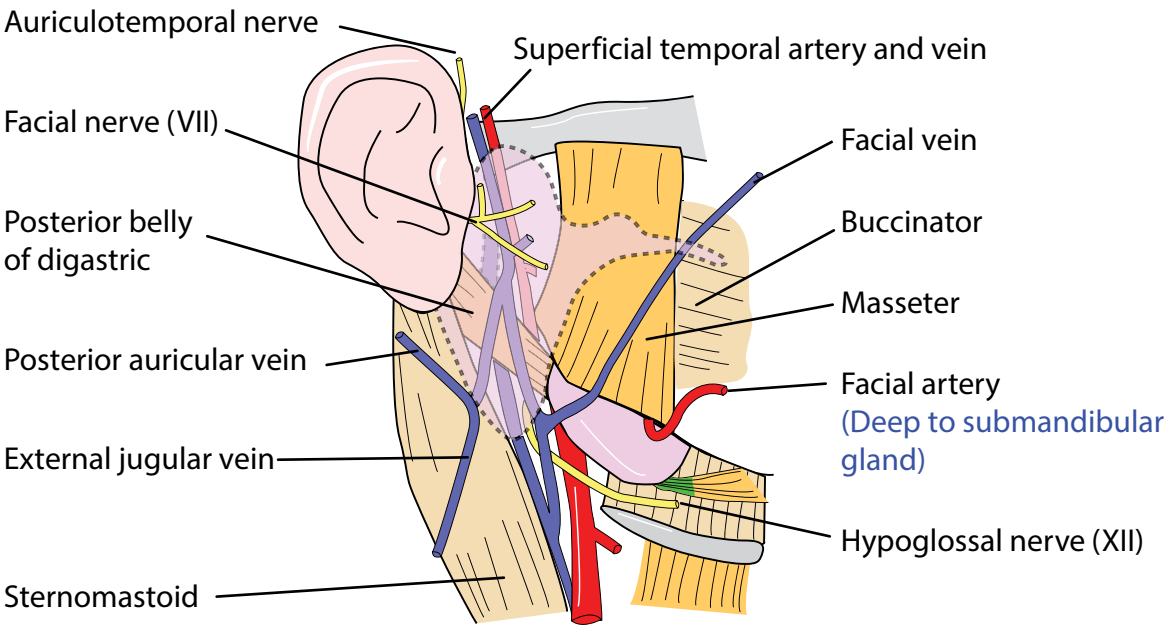
Posterior view of thyroid gland



- 4 (3-6) pinkish/brown 50mg glands.
- 6x3x2mm
- **Usually lie:** Within pretracheal fascia
  Superior: Less variation in position
  Inferior: More variation, even into upper mediastinum
- **Blood supply:** Inferior thyroid arteries
- **Nerves:** Sympathetics on arteries for vasoconstriction
- **Function:** Produce parathormone (PTH), increases tubular reabsorption of calcium, decrease tubular reabsorption of phosphate/ bicarbonate, mobilise calcium from bones to give hypercalcaemia and hypercalciuria

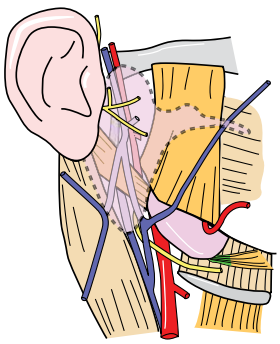
5.16 Parotid and Submandibular Glands

PAROTID GLAND



The parotid gland lies between mastoid, styloid processes and ramus of mandible. Surrounded by TIGHT parotid fascia (investing layer of deep fascia).

Secretomotor supply: Parasympathetic from lesser petrosal from glossopharngeal (IX)



RELATIONS:

Posterior
Sternocleidomastoid
Mastoid process

Superior
External acoustic meatus
Temporomandibular joint

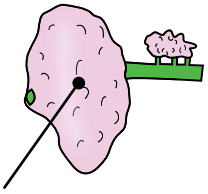
Anterior
Angle of mandible
Medial pterygoid plate
Masseter
Stylomandibular ligament

PAROTID GLAND

Serous secretions: Produces amylase, water, Ig factors (lubicates and aids oral hygiene). **Parts:** Has an upper and lower pole, lateral, anterior and deep surfaces

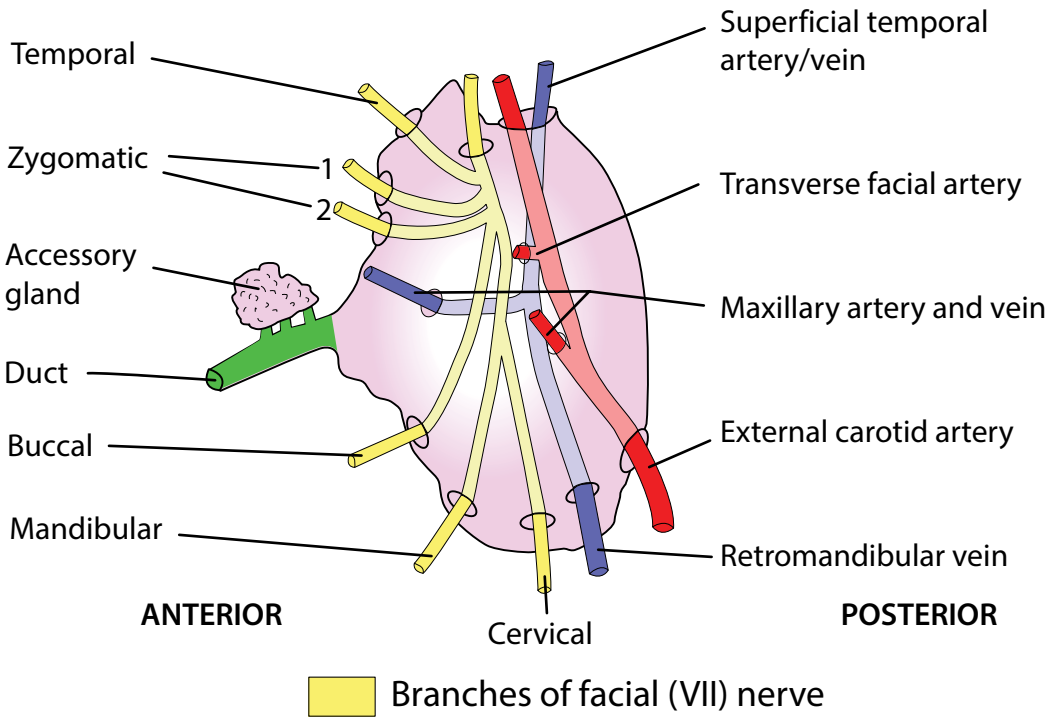
In gland: Facial nerve, retromandibular vein, external carotid artery, lymph nodes and fibres of auriculotemporal nerve

Deep to gland: Mastoid process, sternomastoid, posterior belly of digastric, styloid process, stylohyoid ligament, styloglossus, stylopharyngeus and tempormandibular joint

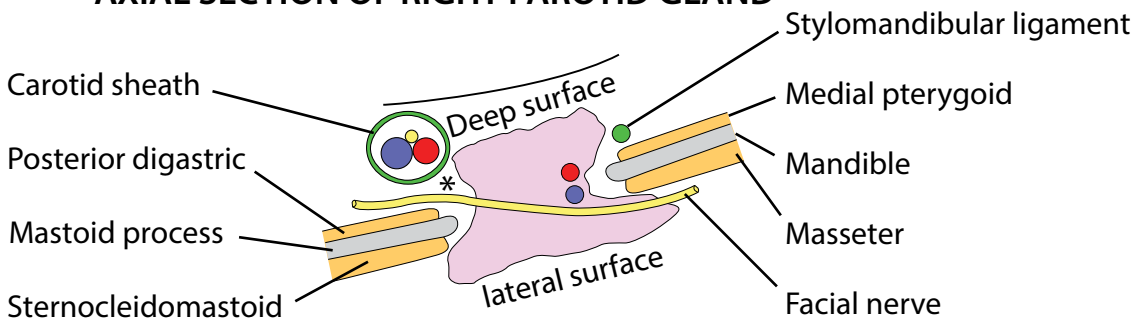


Lateral subcutaneous surface

MEDIAL SURFACE OF RIGHT PAROTID GLAND



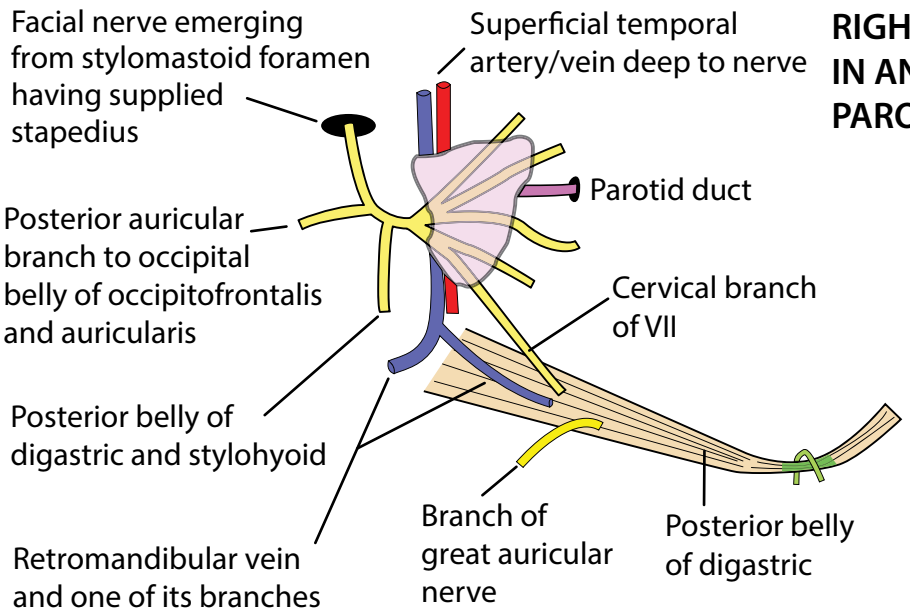
AXIAL SECTION OF RIGHT PAROTID GLAND



- **Artery:** Branches of external carotid. **Vein:** Retromandibular
- **Lymph:** Pre-auricular to deep cervical
- **Nerves:** Secretomotor - via inferior salivary nucleus to glossopharyngeal nerve to its tympanic branch to lesser petrosal nerve to otic ganglion to auriculotemporal nerve.
  Sympathetics - via superior cervical ganglion and external carotid artery.
  Sensory - Auriculotemporal (Vc) and great auricular (C2)
- **Duct:** 5cm long, crosses masseter, pierces buccinator at 3rd molar and mucosa at 2nd molar

* Styloid process, stylohyoid, styloglossus, stylopharyngeus, stylohyoid and stylomandibular ligaments

RIGHT FACIAL NERVE IN AND BEFORE THE PAROTID GLAND

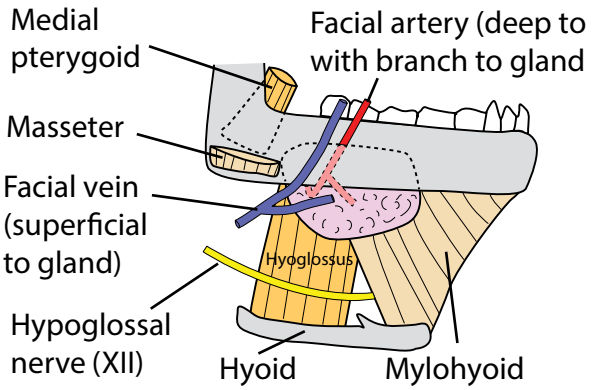


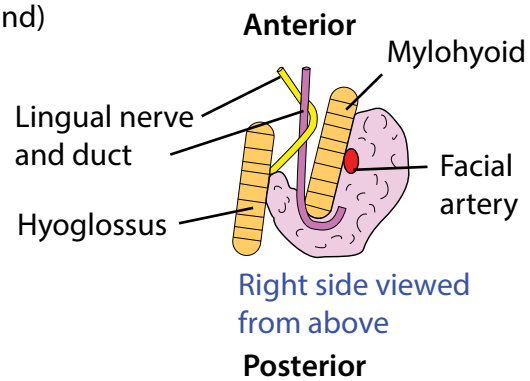
Note: Only three important structures lie anterolateral to the posterior belly of digastric:-

- Cervical branch of facial nerve (VII)
- Branch of the retromandibular vein
- Branch of great auricular nerve (cervical plexus)

SUBMANDIBULAR GLAND

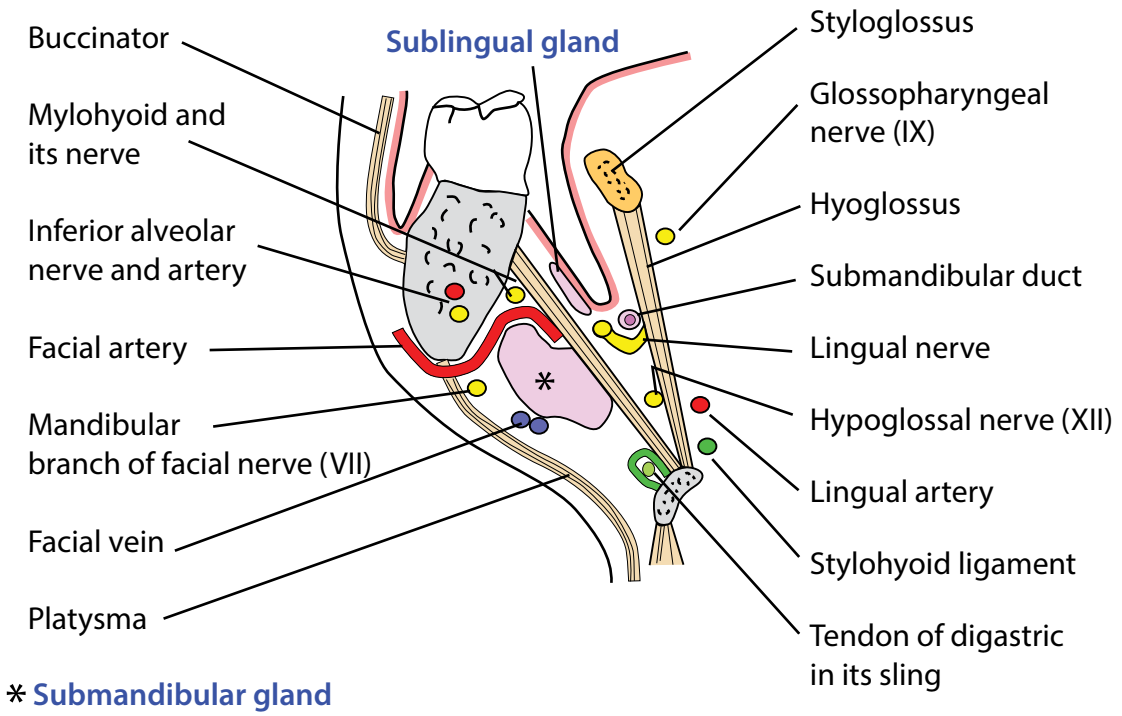
Secretions: Mixed - Mucous and serous
2 parts: Superficial - larger. Deep - smaller. Join behind posterior edge of mylohyoid
Duct: (Wharton's) 5cm long. First between mylohyoid and hyoglossus, then between sulingual gland and geniohyoid. **Opens:** In floor of mouth beside frenulum.
Develops: In ectoderm from a groove in the floor of mouth.
Produces: 70% of the saliva
Lymph nodes: In it and on it. Drain to submandibular glands.
Secretomotor supply: Chorda tympani from superior salivary nucleus carried on VII





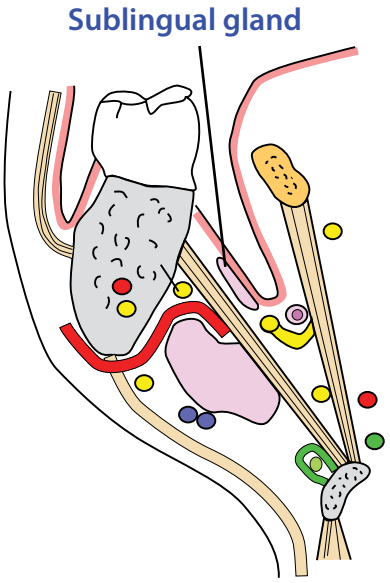
SUBMANDIBULAR AND SUBLINGUAL GLANDS

Coronal section

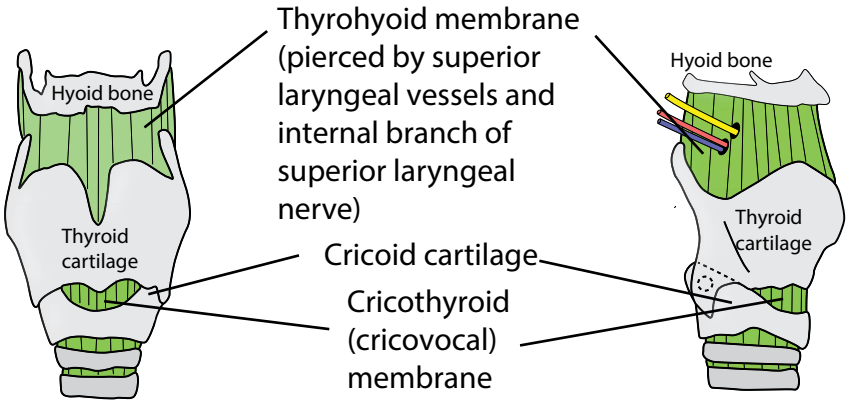


SUBLINGUAL GLAND

- Mucous gland
- Between mylohyoid and genioglossus
- 15 ducts - Half into submandibular duct; half into sublingual fold
- **Nerve supply:** Secretomotor via submandibular ganglion from chorda tympani; general sensation via lingual nerve (Vc)
- **Blood supply:** Lingual artery and branches of submental artery
- **Develops:** from a groove in floor of mouth that becomes a tunnel. Blind end proliferates (ectodermal) to give secreting acini
- **(Note: all salivary glands develop from epithelial lining of mouth)**

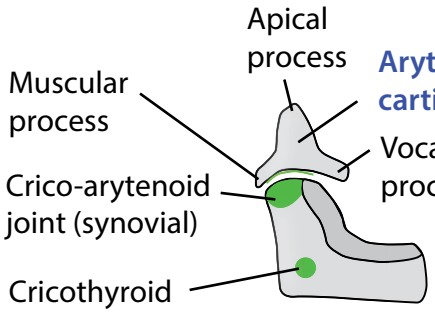


5.17 Larynx and Pharynx

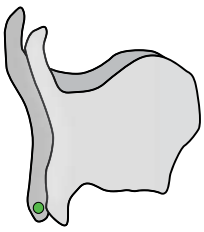


LARYNX - BONES AND CARTILAGES

Larynx is elevated by: Mylohyoid, digastric, stylohyoid, geniohyoid, thyrohyoid, stylopharyngeus, palatopharyngeus, salpingopharyngeus, Inferior constrictor



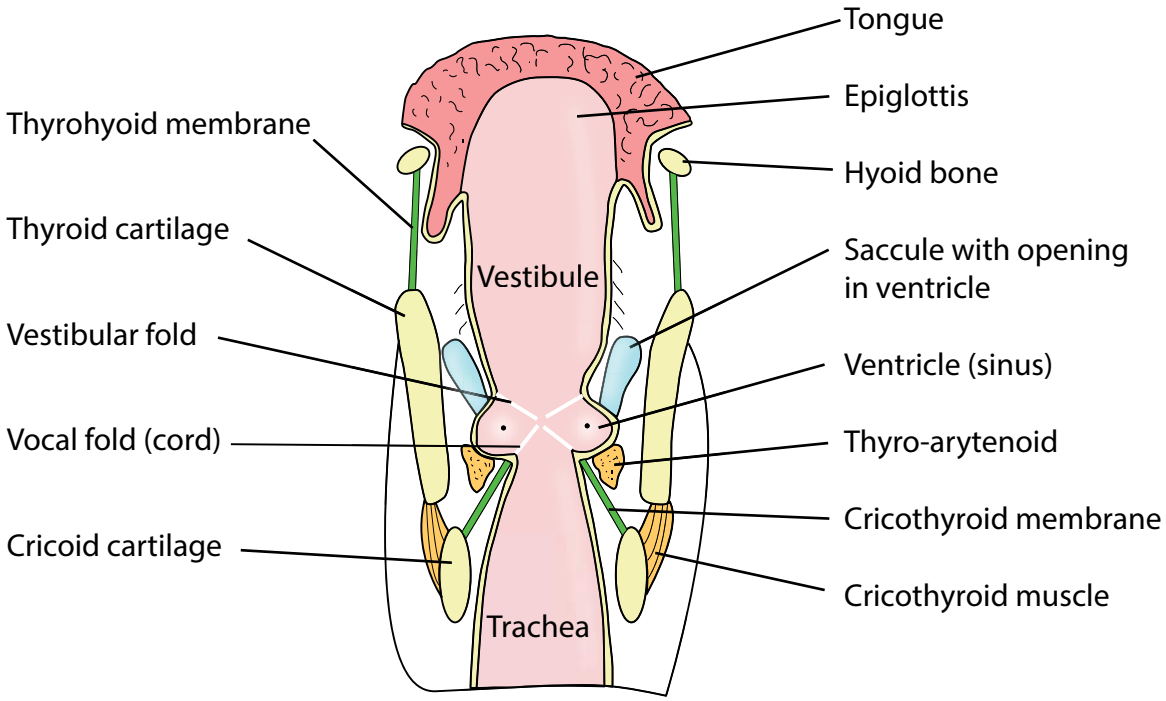
Cricoid cartilage
- Complete signet-like ring of cartilage



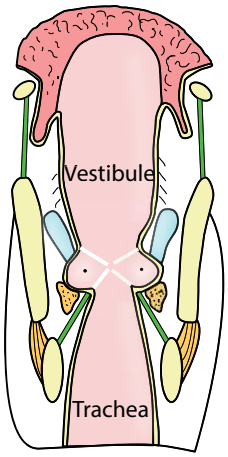
Thyroid cartilage
- **Shield like**

LARYNX - CORONAL SECTION

Viewed from behind so looking anteriorly

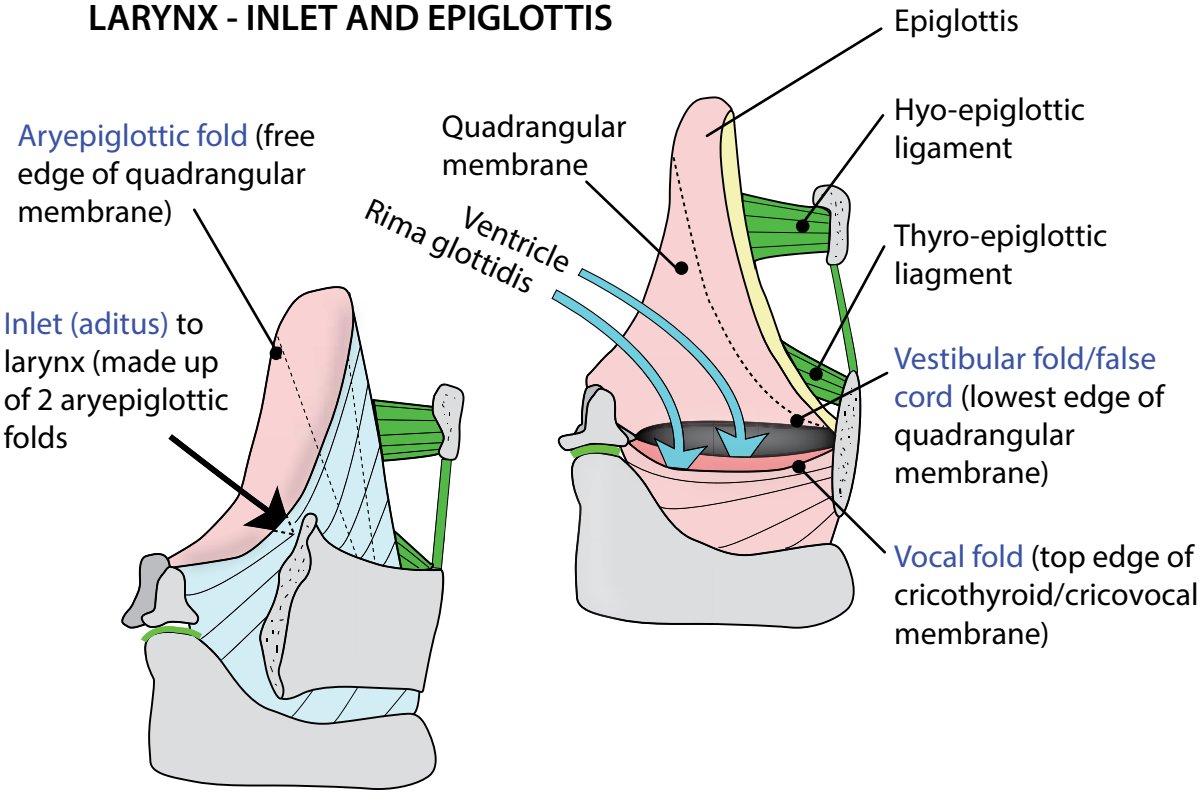


LARYNX

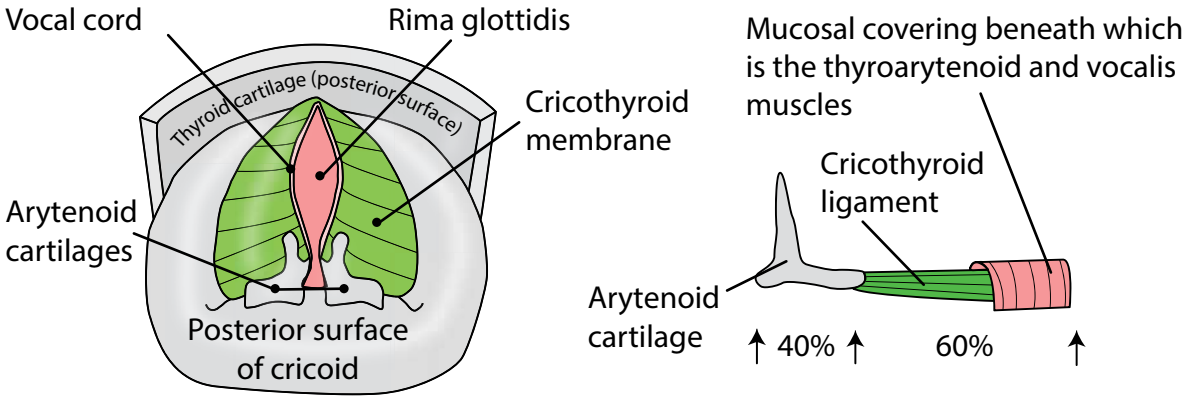


Mucosa: Pseudostratified ciliated columnar. Mucous glands in sinus. (Cords and upper epiglottis - stratified squamous)
Blood supply: Superior and inferior laryngeal arteries
Nerve supply:
Sensory above cords - Internal branch of superior laryngeal nerve from vagus (arch 4 nerves)
Sensory below cords - Recurrent laryngeal nerve branch of vagus (arch 6 nerves)
Motor to muscles: Nucleus ambiguus via cranial accessory nerve to vagus
Cricothyroid: External branch of superior laryngeal nerve.
All other laryngeal muscles (including upper oesophagus and cricopharyngeus): Recurrent laryngeal nerve
Lymphatic drainage:
Above cords: Upper deep cervical nodes
Below cords: Lower deep cervical nodes

LARYNX - INLET AND EPIGLOTTIS

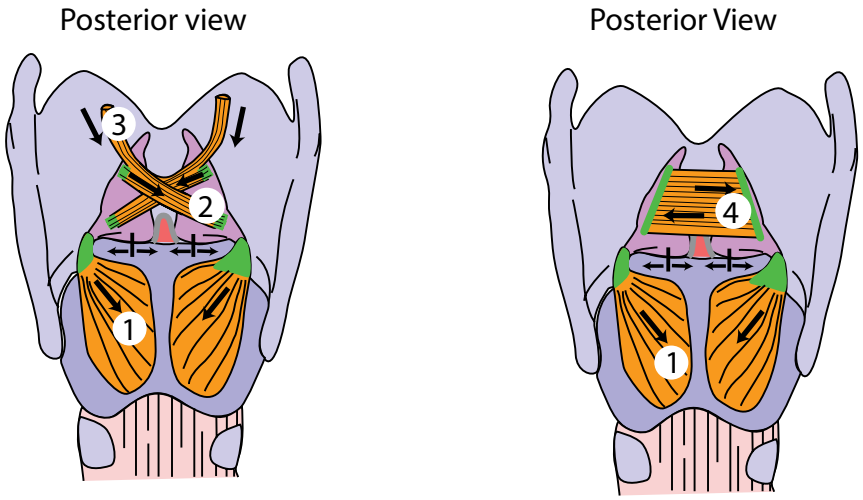


VOCAL CORDS AND CRICOTHYROID MEMBRANE



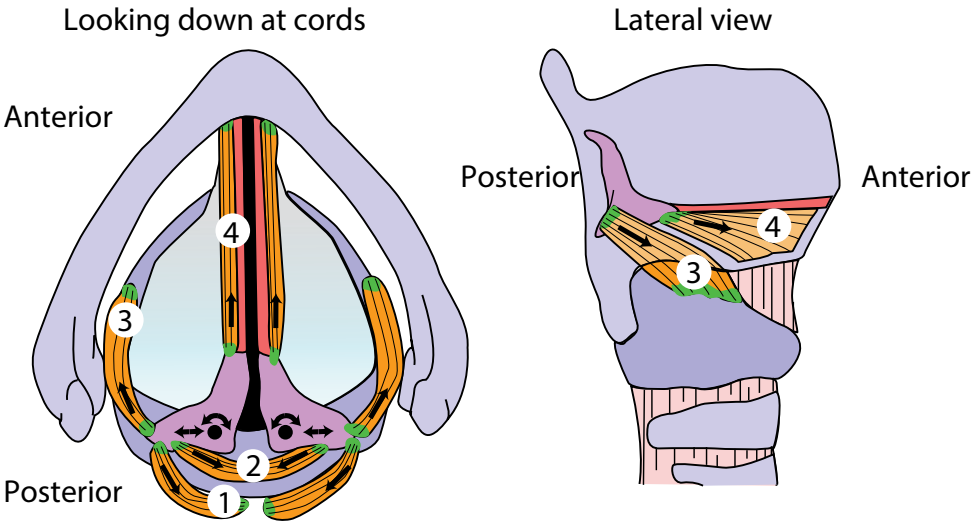
TRUE VOCAL CORDS are the free upper edges of the cricothyroid membrane (conus elasticus) where it is thickened to become the cricovocal liagment and covered with mucosa. The mucosa is pearly white and has no submucosa and thus in theory should not become oedematous, but in practice they do as in anaphylaxis and infection. 40% of the vocal cord is arytenoid cartilage: 60% is membrane. The cricothyroid membrane is attached around the inside of the ring of cricoid cartilage and has a free upper margin that is attached to the arytenoid cartilages posteriorly and to the posterior of the thyroid cartilage anteriorly

INTRINSIC MUSCLES OF THE LARYNX 1



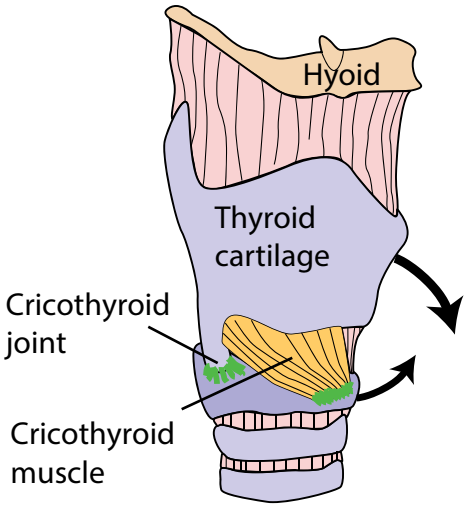
1. Posterior crico-arytenoid: **Abducts and open cords - only muscle to do so**
2. Oblique arytenoid: **Close cords by drawing together the arytenoids**
3. Aryepiglotticus: **Close aditus. They are the extension of aryepiglotticus**
4. Transverse arytenoid: **Close cords by drawing together the arytenoids**

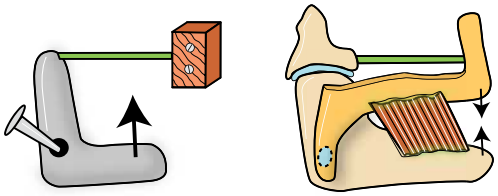
INTRINSIC MUSCLES OF THE LARYNX 2



1. Posterior crico-arytenoid: **Open cords - only muscle to do so**
2. Transverse arytenoid: **Close cords**
3. Lateral crico-arytenoid: **Adduct and close cords by rotating arytenoids medially**
4. Thyro-arytenoid: **Loosen cords by pulling the thyroid cartilage towards the arytenoids**
4. Vocalis (part of thyro-arytenoid): **Alter shape and thickness of cords**

CRICOTHYROID MUSCLE





The action of cricothyroid can be likened to nailing an angle iron to the wall, as above, and levering it upwards. The attached cord will tighten

Only muscle of larynx that:

- Is outside the larynx
- Is supplied by external branch of superior laryngeal nerve
- Tightens(lengthens) the cords

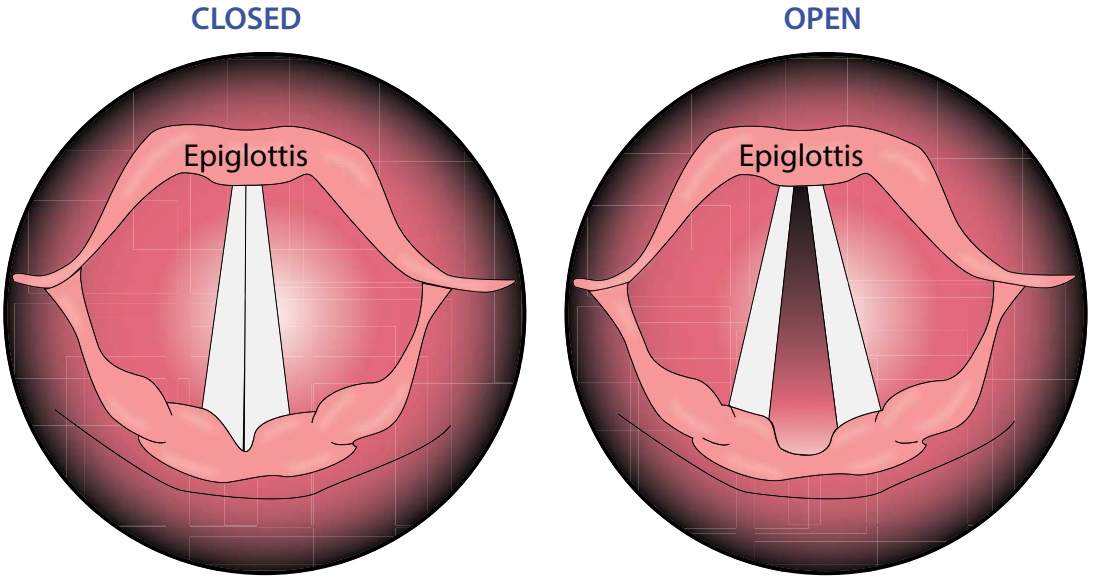
Mucosa of larynx: Pseudostratified ciliated columnar BUT squamous over cords and top of epiglottis.

Lymphatic drainage:

Above cords - upper deep cervical nodes

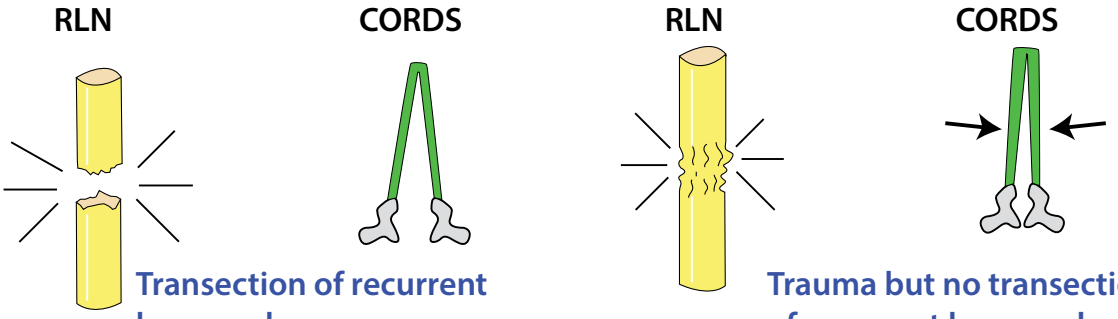
Below cords - lower deep cervical nodes

VOCAL CORDS



The vocal cords open by the arytenoid cartilages sliding down the slope of the cricoid cartilage and thus open as a "triangle" shape and not as a "diamond" shape

SEMON'S LAW: DAMAGE TO THE RECURRENT LARYNGEAL NERVE



Transection of recurrent laryngeal nerve

- Complete paralysis of all muscles that open and close cords
- Cords lie half ab/adducted
- Cannot cough or speak

BILATERAL → DISASTER
UNILATERAL → CAN COMPENSATE

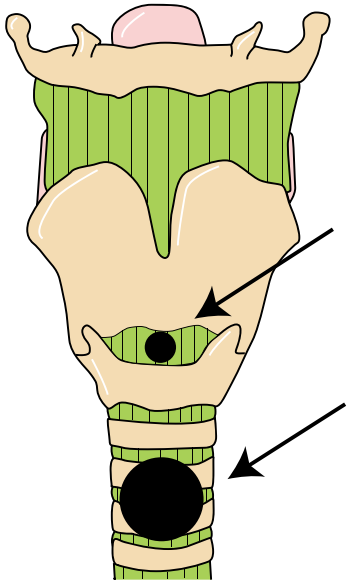
Trauma but no transection of recurrent laryngeal nerve

Partial paralysis gives adducted cords as 6 pairs of muscles, though partially disabled, still manage to close the cords. The partially damaged posterior crico-arytenoids are overwhelmed and fail to opens them. Patient cannot breathe.

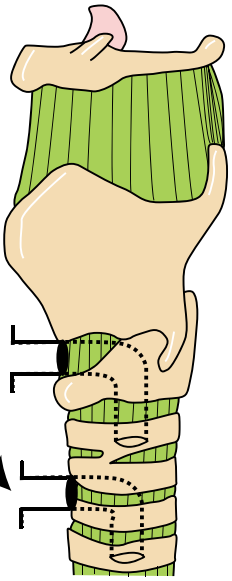
Semon's Law indicates the different effect between damage and transection of the recurrent laryngeal nerve as applicable to surgery in the region of this nerve (eg thyroidectomy or parathyroidectomy). It

EMERGENCY ACCESS TO TRACHEA

Anterior



Lateral



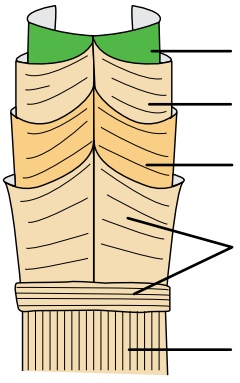
CRICOTHYROIDOTOMY

Quick, relatively easy stab through cricothyroid membrane. Insert any small round airway such as a biro casing. Anaesthetic not essential. Life saving

FORMAL TRACHEOSTOMY

Not usually such an emergency. Needs full anaesthetic. Ideal for temporary or permanent intubation. Hole cut in 2nd and 3rd tracheal rings, usually after dividing thyroid isthmus. Inferior thyroid veins can be troublesome. 1st ring should be avoided as damage to it may lead to subsequent stenosis

PHARYNX - CARTOON OF MUSCLES AND PHARYNGOBASILAR FASCIA



Pharyngobasilar fascia

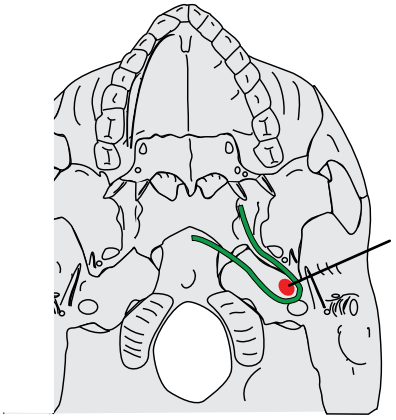
Superior constrictor

Middle constrictor

Inferior constrictor (thyro/crico-pharyngeus)

Oesophagus

LIKE 4 STACKED CUPS



Levator palati

PHARYNGOBASILAR FASCIA (green):
A rigid membrane with cartilage of auditory tube passing just above it.
Arises: Base of skull as shown
Lower border: Junction of hard and soft palates
Note: Levator palati arises from within it. The only muscle that does

PHARYNX - MUSCLES AND STRUCTURES ENTERING IT

Between superior and middle constrictors:

1. Glossopharyngeal nerve (IX)
2. Stylopharyngeus (IX)
3. Stylohyoid ligament
4. Lingual nerve (Vc)

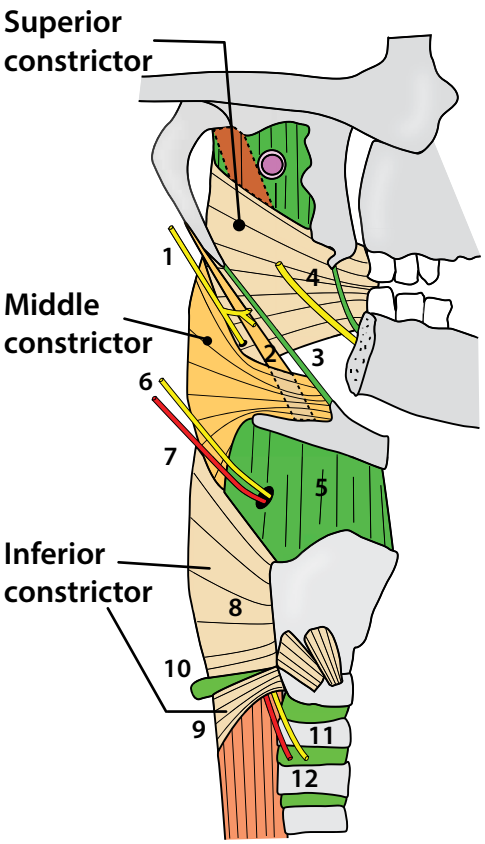
Between middle and inferior constrictors:

5. Thyrohyoid membrane pierced by -
6. Internal laryngeal nerve
7. Superior laryngeal vessels

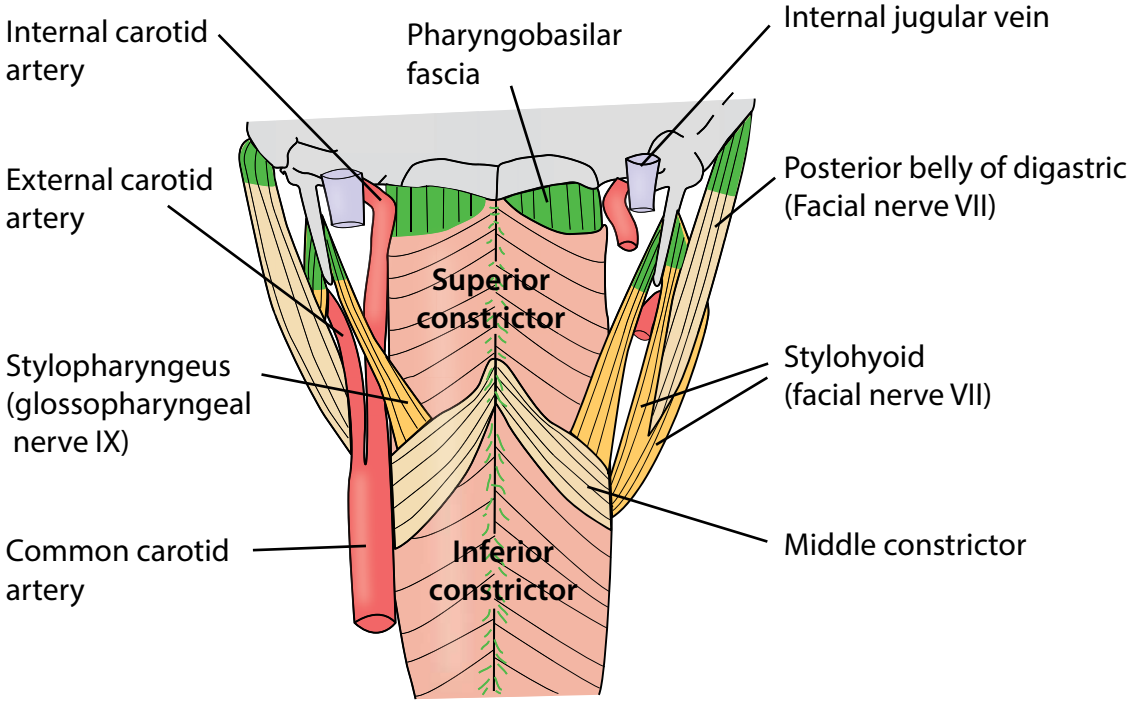
(Thyropharyngeus (8) is upper part that behaves like the other constrictors, closing on swallowing. Cricopharyngeus (9) is lower part - a sphincter that opens on swallowing. Between 2 parts is potential pharyngeal pouch (Dehiscence of Killian) (10)

Below inferior constrictor and passing upwards:

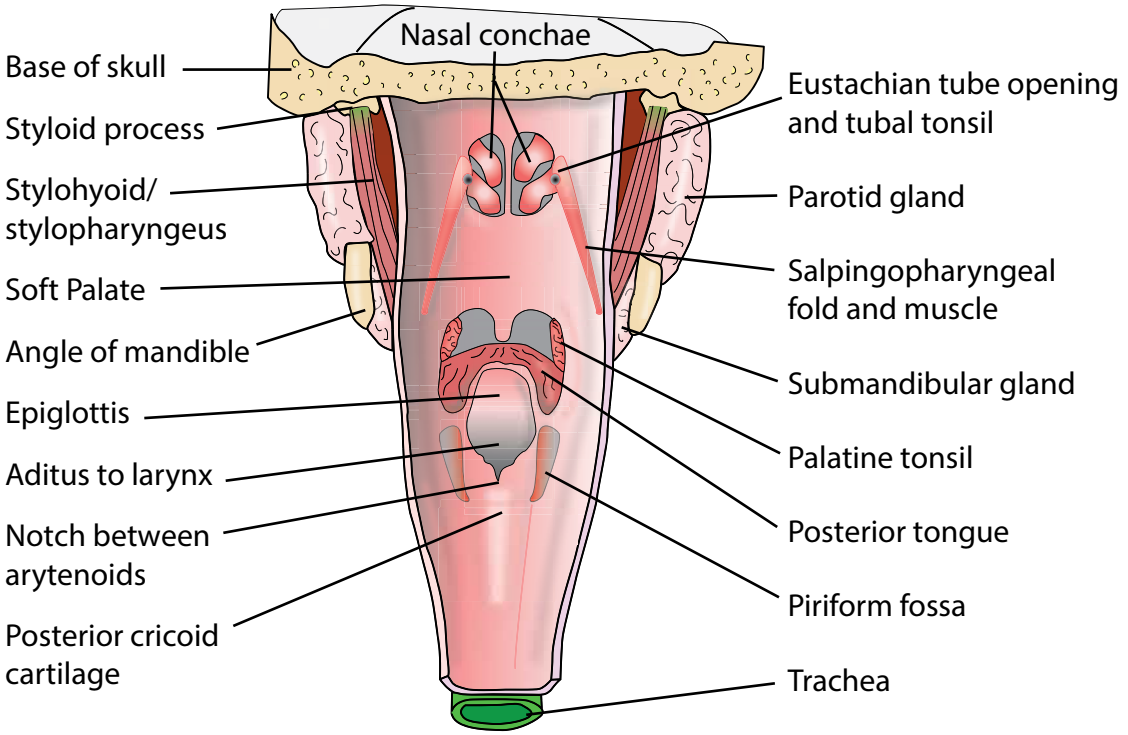
11. Recurrent laryngeal nerve
12. Inferior laryngeal vessels



STYLOID PROCESS MUSCLE AND LIGAMENT ATTACHMENTS POSTERIOR VIEW

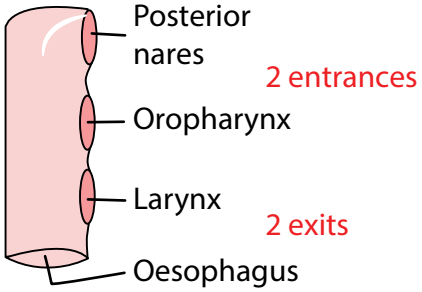


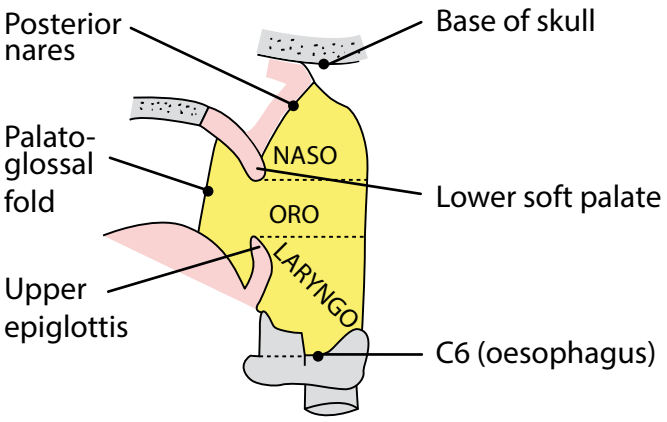
NASAL, ORAL AND LARYGOPHARYNX OPENED POSTERIORLY



3 PARTS OF THE PHARYNX

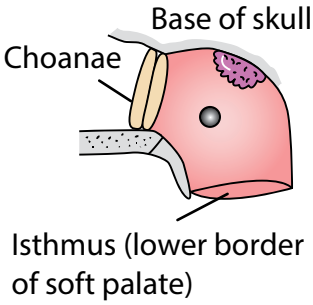
CARTOON OF PHARYNX

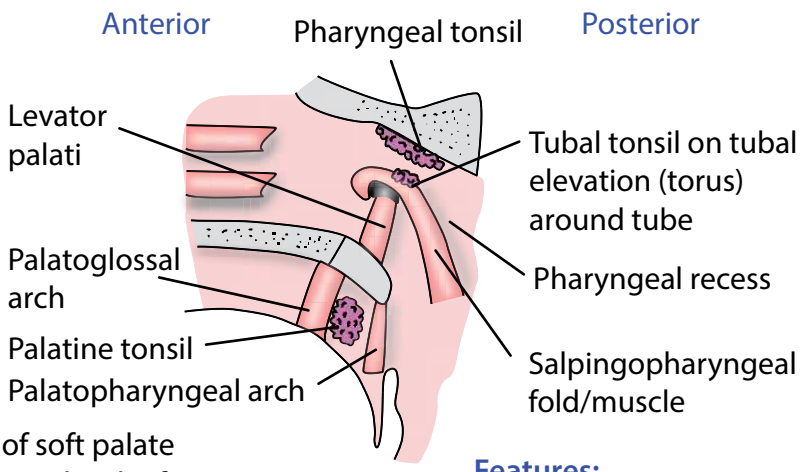




- 5" (13cm) long fibromuscular tube suspended from skull. Anterior to prevertebral fascia like a mask applied to back of face
- **Extends:** From nose to C6 (oesophagus)
- **Walls:** Mucous membrane, fibrous submucosa, muscle and buccopharyngeal fascia
- **Muscles:** 3 constrictors + stylopharyngeus, palatopharyngeus, salpingopharyngeus
- **Note:** Levator palati is wholly intra-pharyngeal

NASOPHARYNX - RIGHT 1





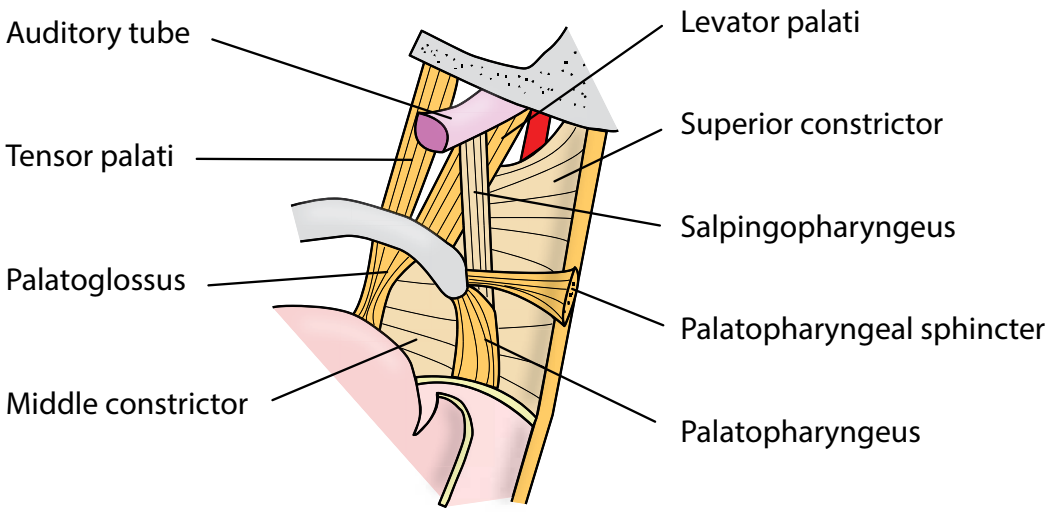
- Choanae to inferior border of soft palate
- **Posterior and lateral:** Pharyngobasilar fascia
- **Posterior:** Prevertebral space/fascia, body of C1 vertebra
- **Anterior:** Choanae and back of soft palate
- **Inferior:** Soft palate and pharyngeal isthmus
- **Superior:** Pharyngeal tonsil (adenoid), sphenoid and occiput
- **Epithelium:** Ciliated columnar
- **Nerve:** Pharyngeal branch of Vb

Features:

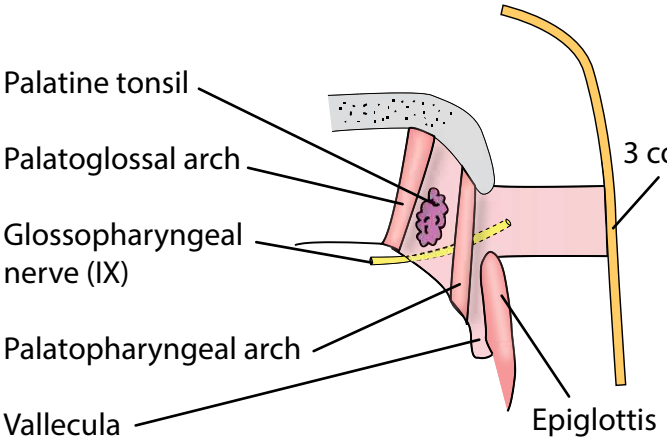
- Opening of auditory tube
- Pharyngeal tonsil
- Tubal tonsil
- Pharyngeal recess (of Rosenmuller)
- Salpingopharyngeus and levator palati

NASOPHARYNX - RIGHT 2

Mucosa removed to show muscles



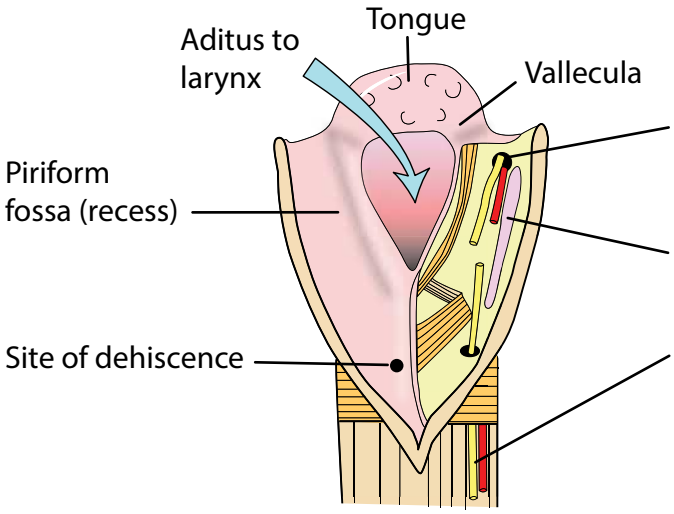
OROPHARYNX - RIGHT



GAG REFLEX
Sensory: Glossopharyngeal (IX)
Motor: Pharyngeal plexus to palate muscles. (IX, X, Sympathetic)

- Lower border of soft palate to upper border of epiglottis
- **Anterior:** Posterior aspect of tongue and palatoglossal arch
- **Posterior:** 3 constrictors and C2/C3 vertebrae
- **Inferior:** Back of tongue, lingual tonsil and valleculae
- **Lateral:** Palatoglossal/palatopharyngeal arches, constrictors and palatine tonsil
- **Lining:** Squamous epithelium
- **Nerves:** Glossopharyngeal (IX) and internal laryngeal (X) in valleculae
- **Features:** Palatine tonsils, lingual tonsils, valleculae

LARYNGOPHARYNX



- From tip of epiglottis to start of oesophagus - C6
- **Anterior:** Larynx, aditus, epiglottis
- **Posterior:** 3 constrictors, cricopharyngeus, vertebrae C4,5,6
- **Nerves:** Internal laryngeal branch of superior laryngeal nerve (X) and recurrent laryngeal nerve (X). (Some overlapping of supply in the laryngopharynx unlike in the larynx)
- **Lining:** Squamous non-keratinising epithelium
- **Features:** Aditus to larynx and piriform fossa

SWALLOWING

1. **FOOD BOLUS MOVED BY TONGUE TO OROPHARYNX**
Mylohyoid (Vc) lifts tongue - Tongue (XII) - Styloglossus - Muscles of mastication (Vc) - Buccinator (VII)
2. **NASOPHARYNX CLOSES**
Superior constrictor (PP- pharyngeal plexus) - Passavant's ridge (PP) - Tensor palati (Vc) - Levator palati (PP)
3. **AUDITORY TUBE OPENS**
Levator palati (PP) - Tensor palati (Vc) - Salpingopharyngeus (PP)
4. **PHARYNX AND LARYNX MOVE UP TO HYOID**
Happens before bolus arrives - Stylopharyngeus (IX) - Salpingopharyngeus (PP) - Palatopharyngeus (PP) - Inferior constrictor (PP)
5. **OROPHARYNX KEPT CLOSED**
Palatoglossus (PP) - Intrinsic muscles of tongue (XII) - Styloglossus (XII)
6. **LARYNX CLOSES**
Aryepiglotticus (X-RLN) - Cords close (X-RLN) - Epiglottis flaps
7. **HYOID ELEVATES BRINGING PHARYNX/LARYNX UP MORE**
Stylohyoid (VII)
8. **HYPOPHARYNX OPENS**
Cricopharyngeus/upper oesophagus relax (X-RLN)
9. **HYOID, LARYNX AND PHARYNX MOVE DOWN TOGETHER**
Elastic recoil
10. **LARYNX AND PHARYNX MOVE DOWN FROM HYOID**
Elastic recoil
11. **PERISTALSIS**
Striated muscle then smooth muscle of oesophagus (3-5cm/sec) (X-RLN)

ORDER OF EVENTS IN SUMMARY

LARYNX AND PHARYNX MOVE UP TO HYOID

↓

LARYNX, PHARYNX AND HYOID MOVE UP

↓

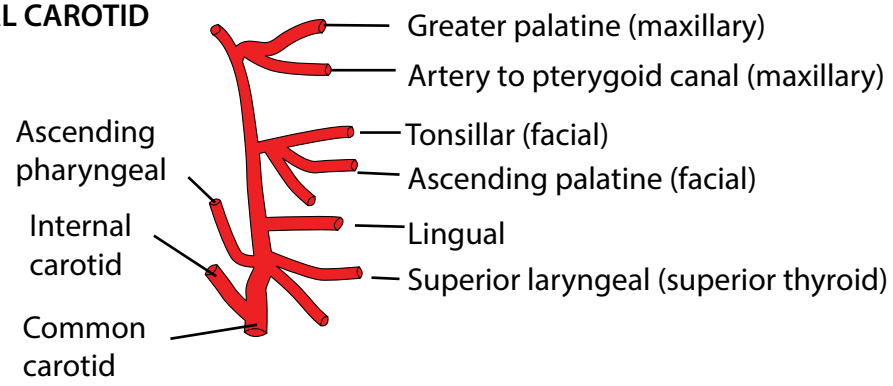
LARYNX, PHARYNX AND HYOID MOVE DOWN

↓

LARYNX AND PHARYNX MOVE DOWN FROM HYOID

VASCULAR SUPPLY TO PHARYNX

ARTERIAL SUPPLY FROM EXTERNAL CAROTID



VENOUS DRAINAGE

Plexus on middle constrictor draining to:
Pterygoid plexus
Internal jugular vein
Lower pharynx to inferior thyroid veins

NERVES OF THE PHARYNX

PHARYNGEAL PLEXUS

On posterior wall of pharynx.
IX (glossopharyngeal) sensory only.
X (pharyngeal branch of vagus).
Branchiomotor fibres from nucleus ambiguus via cranial accessory (XI)
Sympathetic - vasocontrictor only

Supplies →
Levator palati
Salpingopharyngeus
Palatopharyngeus
Palatoglossus
3 constrictors
Striated oesophagus

GLOSSOPHARYNGEAL (IX) →
Stylopharyngeus (motor)
Oropharynx/valleculae (sensation)

RECURRENT LARYNGEAL (X) →
Cricopharyngeus
Upper oesophagus

PHARYNGEAL BRANCH OF MAXILLARY (VB)
via pterygopalatine ganglion and palatovaginal canal
Nasopharynx (sensation)

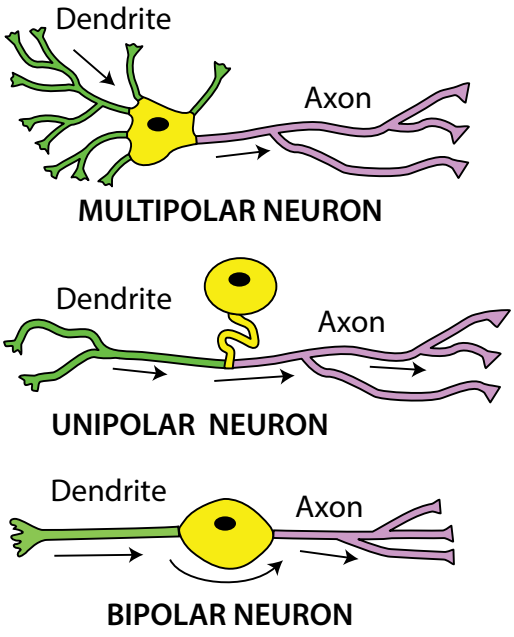
INTERNAL BRANCH OF SUPERIOR LARYNGEAL (X)
Sensation/taste vallecula and upper pharynx

RECURRENT LARYNGEAL (X)
Laryngopharynx

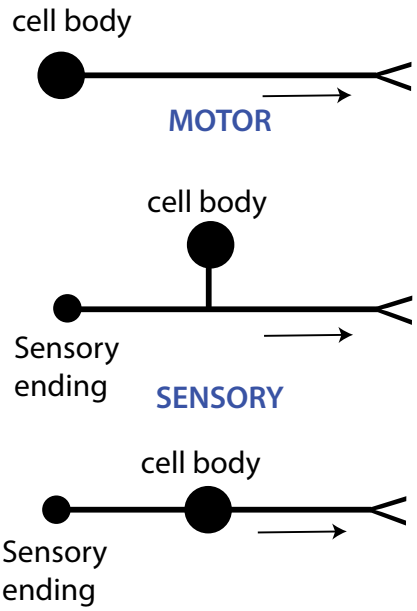
5.18 Autonomic Nervous System, in General, Sympathetic and Parasympathetic

NEURONS

HISTOLOGICAL APPEARANCES



SHORTHAND DRAWINGS



PERIPHERAL NERVOUS SYSTEM

SOMATIC
(Voluntary control)
Motor: Voluntary muscles
Sensory: Localisable

AUTONOMIC
(Involuntary, largely unconscious control)
Motor: Smooth muscle, secretions (glandular, sweat, digestive). Sensory: General visceral afferent and special visceral afferent (taste and baroreception). General, vague, usually midline, poorly-localisable sensation

SYMPATHETIC

Urgent activities: "Flight, Fight, Fright"

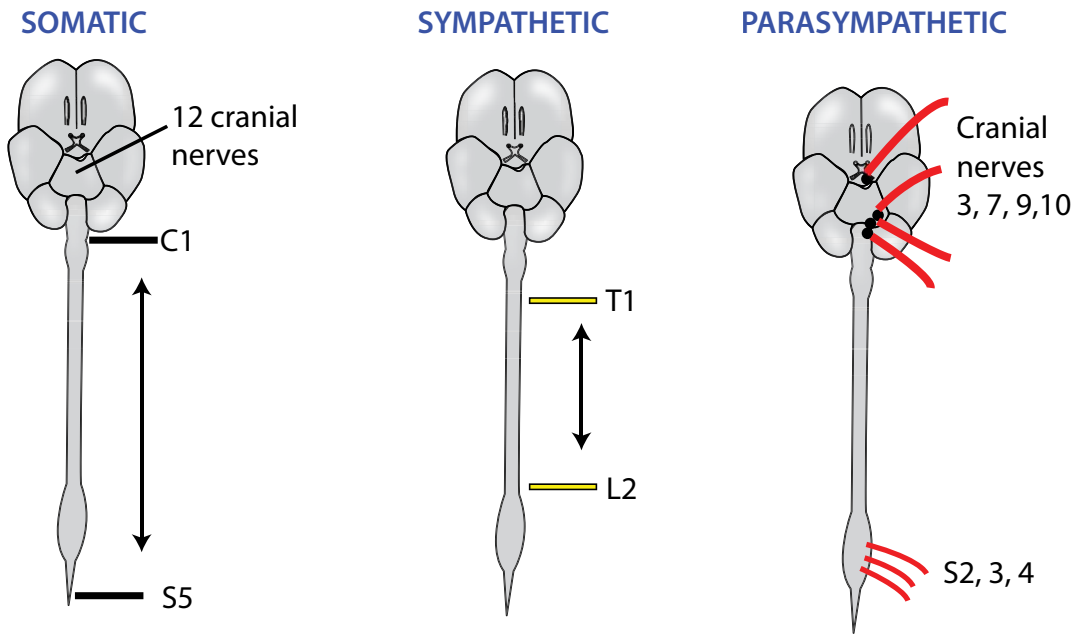
- Increases heart rate, raises blood pressure
- Dilates bronchi
- Dilated pupil
- Raises eyelids
- Vasoconstricts (vasomotor) diverting blood to muscles
- Sweat (sudomotor)
- Erect hairs on skin (pilomotor)
- Stimulates adrenalin from adrenal gland
- Stimulates ejaculation
- Closes sphincters, inhibits peristalsis

PARASYMPATHETIC

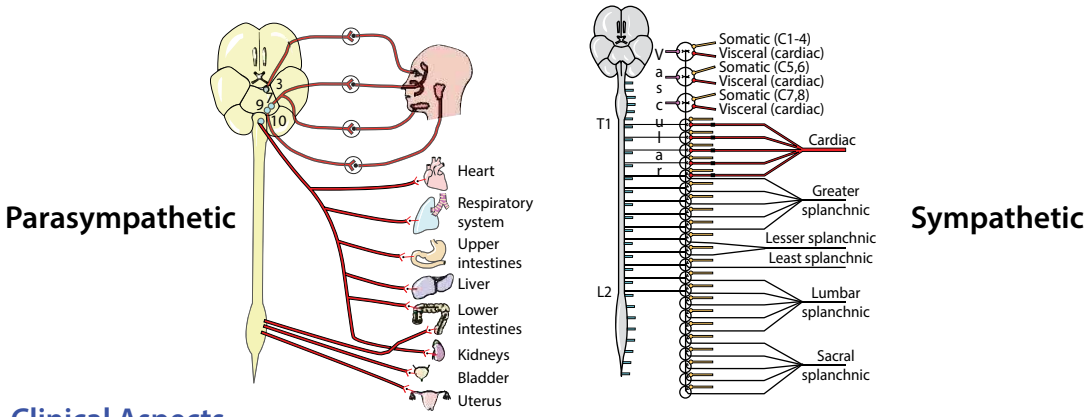
Quiet activities: "Rest and Digest"

- Stimulates secretions (salivary, mucous)
- Slows heart, minimises blood pressure
- Constricts bronchi
- Constricts pupil
- Stimulates gut peristalsis
- Opens sphincters
- Contracts bladder
- Contracts uterus
- Accommodates the eye
- Erects the penis and clitoris

EMERGENCE OF NERVES FROM CENTRAL NERVOUS SYSTEM



AUTONOMIC NERVOUS SYSTEM

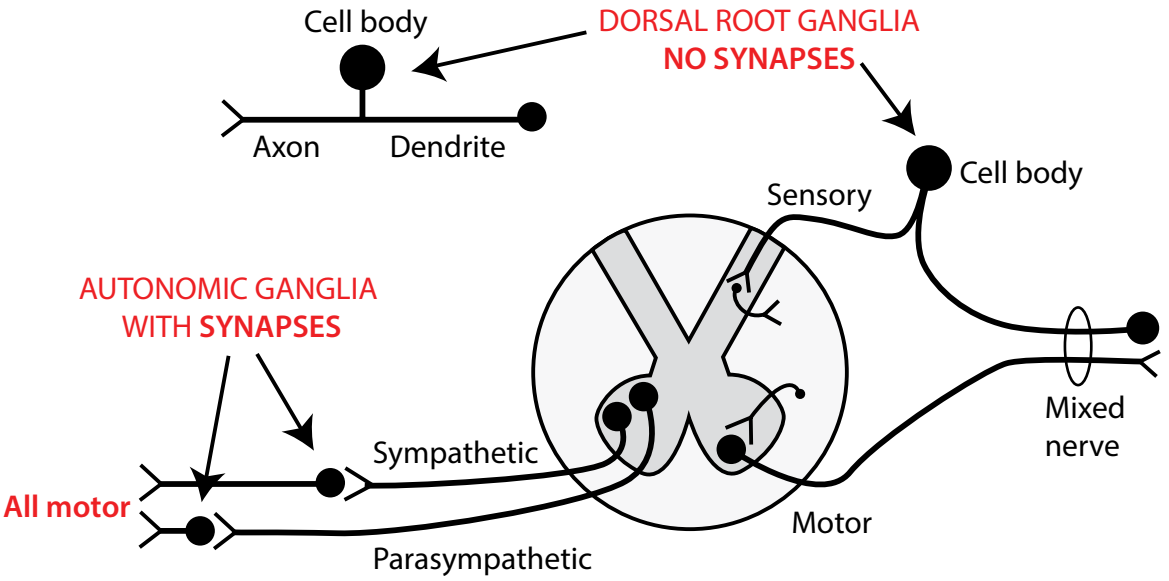


Clinical Aspects

The autonomic system is essential for survival. Without vascular tone we would faint every time we stood up. There would be no intestinal activity to digest and absorb food and no increase in heart rate with exercise. Without sexual activity there would be no continuation of the species!

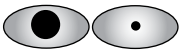
Deliberate destruction of the nerves is sometimes necessary. For instance in excessive sweating, sympathetic nerves can be cut selectively or the parasympathetics (vagus nerves) can be cut to decrease acid production in the stomach. Referred pain, for example from the appendix or gonads, is explicable in terms of general visceral sensory fibres carried in the autonomic system.

AUTONOMIC AND SOMATIC NERVES COMPARED



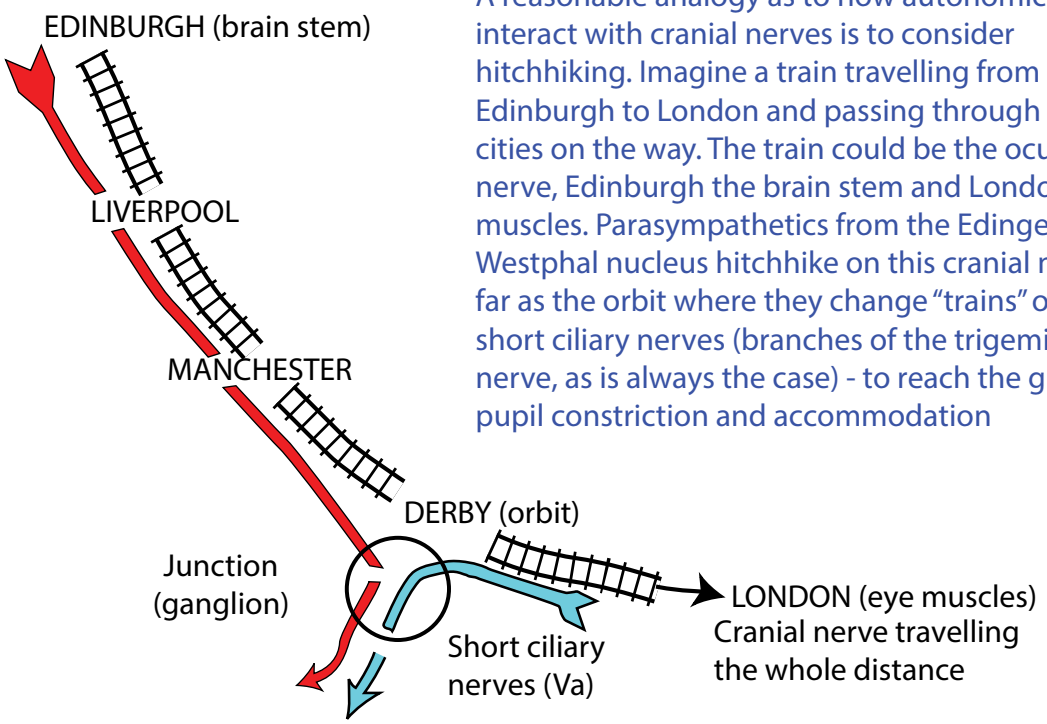
Note: The autonomic nerve system is strictly motor but sensory fibres, for example general visceral afferent and taste, travel with them.

AUTONOMIC NERVOUS ACTIONS
ANTAGONISTIC VERSUS INDEPENDENT ACTIONS

SYMPATHETIC	ANTAGONISTIC	PARASYMPATHETIC
Speeds heart		Slows heart
Dilates bronchi		Constricts bronchi
Dilates pupil		Constricts pupil

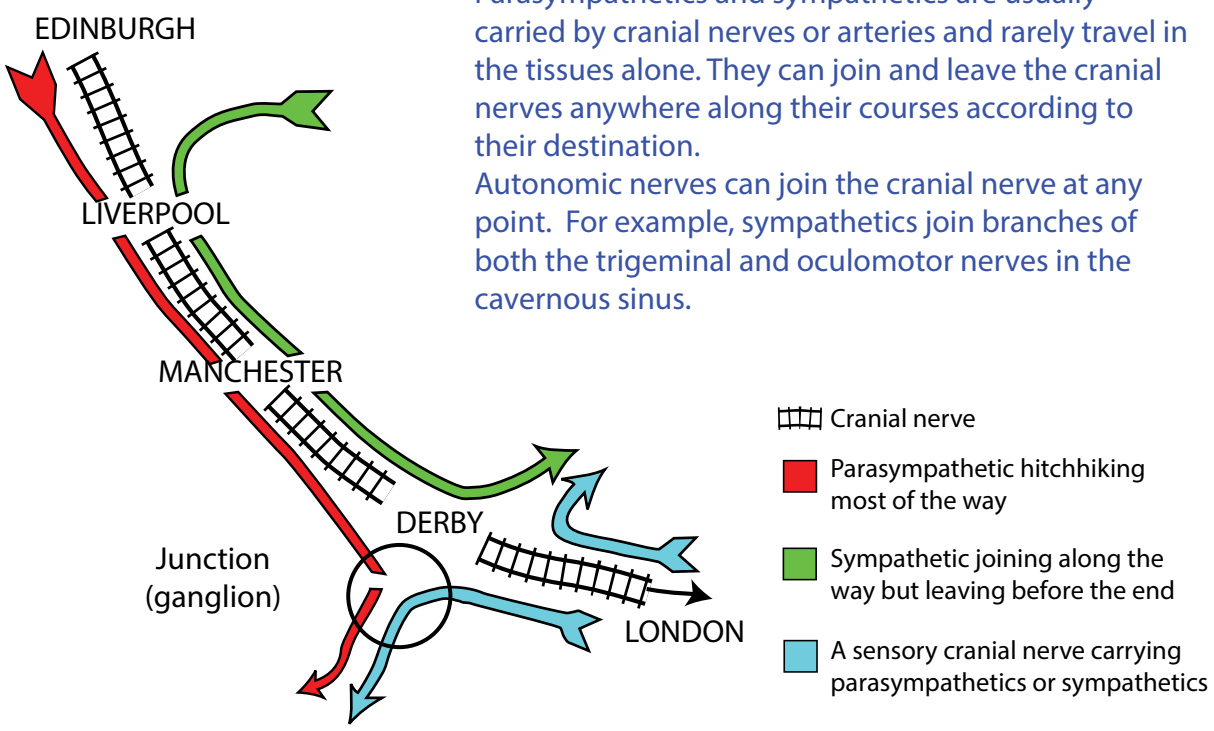
SYMPATHETIC	INDEPENDENT	PARASYMPATHETIC
Raises eyelids		Eye accommodation
Stimulates ejaculation		Erection of penis/clitoris

HITCHHIKING PRINCIPLE 1



A reasonable analogy as to how autonomic nerves interact with cranial nerves is to consider hitchhiking. Imagine a train travelling from Edinburgh to London and passing through various cities on the way. The train could be the oculomotor nerve, Edinburgh the brain stem and London the eye muscles. Parasympathetics from the Edinger Westphal nucleus hitchhike on this cranial nerve as far as the orbit where they change "trains" onto the short ciliary nerves (branches of the trigeminal nerve, as is always the case) - to reach the globe for pupil constriction and accommodation

HITCHHIKING PRINCIPLE 2

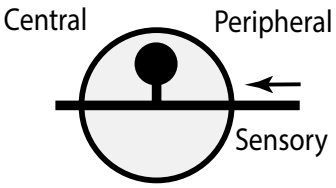


SUMMARY

Parasympathetics and sympathetics are usually carried by cranial nerves or arteries and rarely travel in the tissues alone. They can join and leave the cranial nerves anywhere along their courses according to their destination.

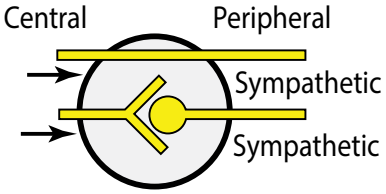
Autonomic nerves can join the cranial nerve at any point. For example, sympathetics join branches of both the trigeminal and oculomotor nerves in the cavernous sinus.

3 TYPES OF GANGLIA



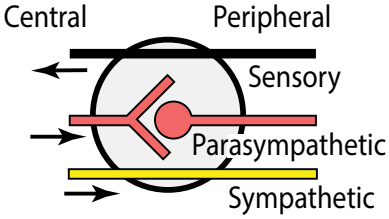
A SENSORY GANGLION has cell bodies only and NO synapses.

Examples:
- Posterior (dorsal) root
- Trigeminal
- Geniculate
- Glossopharyngeal
- Vagal



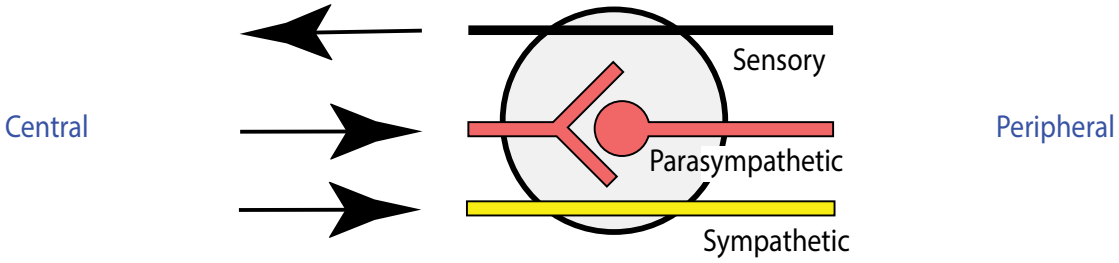
A SYMPATHETIC GANGLION has either a synapse or a fibre passing through it which will synapse later.

Examples:
- Sympathetic chain
- Sympathetic peripheral ganglia (coeliac, renal, superior mesenteric)



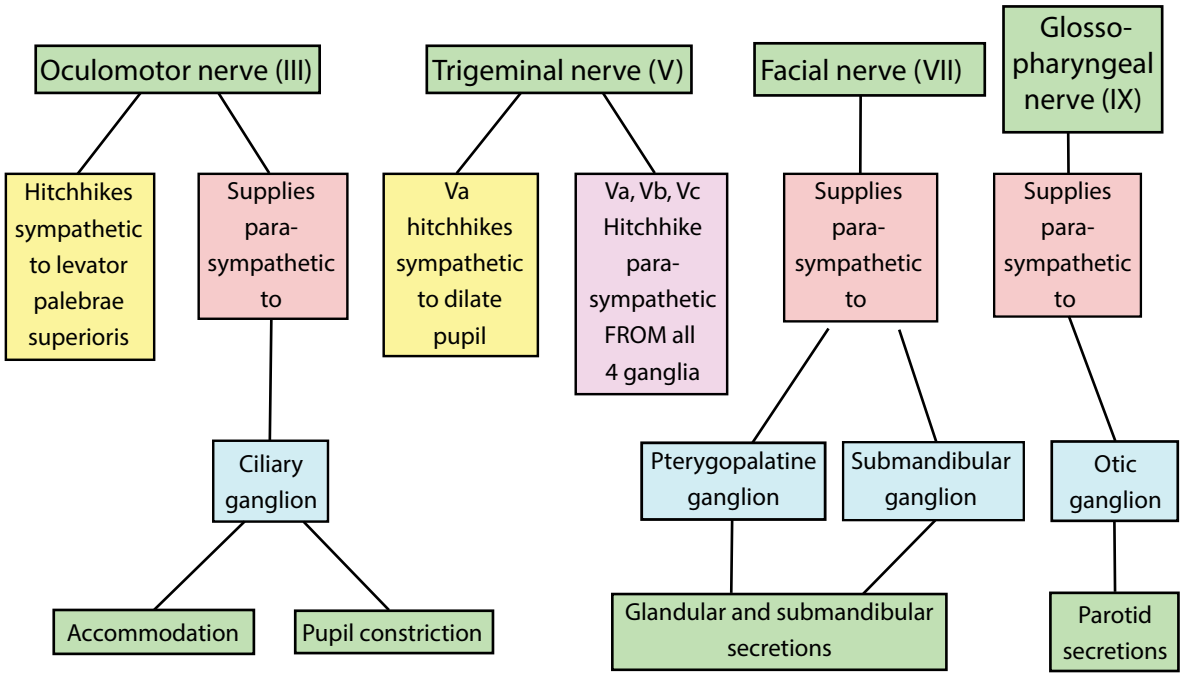
A PARASYMPATHETIC GANGLION has parasympathetic nerves synapsing and both a somatic sensory and a sympathetic nerve passing through it. Examples:
- Ciliary
- Pterygopalatine
- Submandibular
- Otic

PARASYMPATHETIC GANGLIA



All the PARASYMPATHETIC GANGLIA (ciliary, pterygopalatine, submandibular and otic) have the same pattern of a synapse of the parasympathetic fibres and passing through the ganglion is a branch of the trigeminal nerve (somatic sensory) which carries the parasympathetics to their destination. In addition there is a sympathetic fibre passing through for vasoconstriction only.

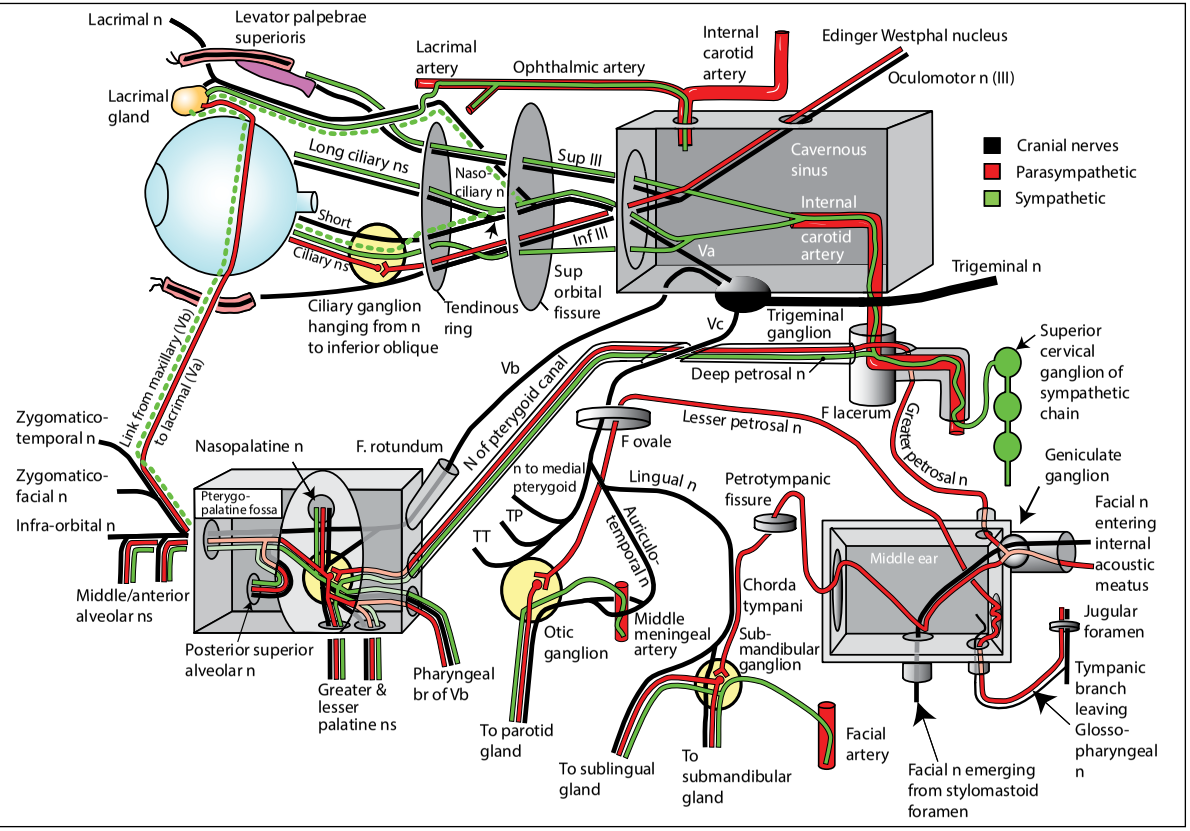
INVOLVEMENT OF CRANIAL NERVES IN AUTONOMIC DISTRIBUTION



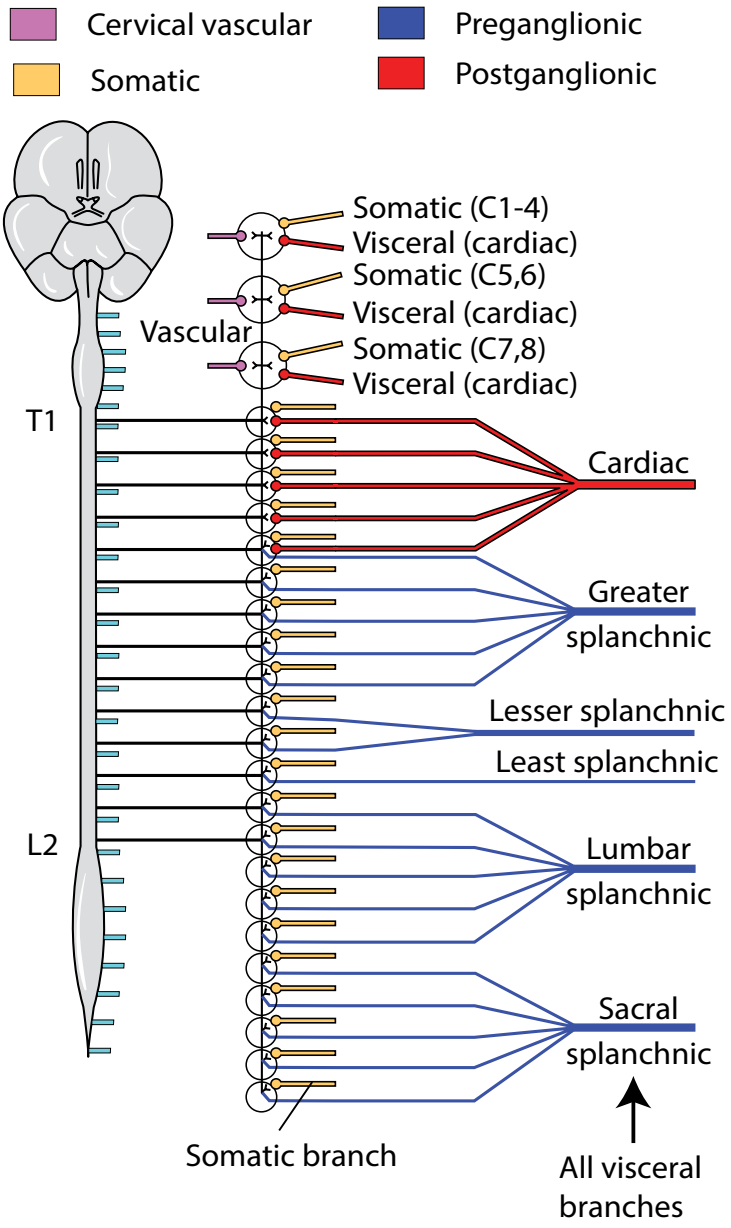
Note: All postganglionic parasympathetics are carried to their destinations by a branch of the trigeminal nerve

AUTONOMIC CONNECTIONS IN THE HEAD

n/ns: Nerve/nerves
TP: Tensor palati
TT: Tensor tympani
V: Divisions of trigeminal nerve
Va - Ophthalmic
Vb - Maxillary
Vc - Mandibular
F - Foramen
br: Branch



SUMMARY OF SYMPATHETIC DISTRIBUTION BEYOND CHAIN



Functions of the sympathetic nerves

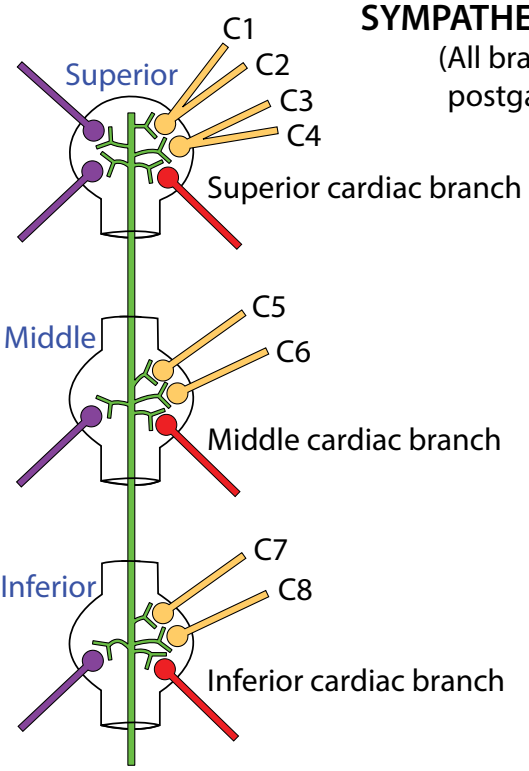
Homeostasis (skin): Sudomotor, pilomotor, vasomotor carried on spinal and cranial nerves.

Homeostasis (other): Vasomotor only, on any convenient nerve or vessel

Specific (to organs): Heart and bronchi. Via splanchnics to all abdominal organs including adrenals, sphincters and pelvic organs. Via superior cervical ganglion to head for pupil dilatation and raising the eyelids.

CERVICAL SYMPATHETIC GANGLIA

(All branches are postganglionic)



Into skull on internal carotid artery for vasoconstriction of its branches, dilatation of the pupil and contraction of levator palpebrae superioris

On external carotid artery on somatic nerves to skin and visceral branches to glands

On inferior thyroid artery: Visceral branches to lower larynx, trachea, hypopharynx, oesophagus

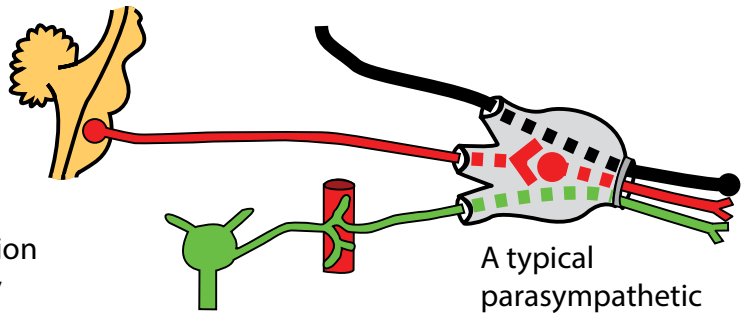
On vertebral artery for vasoconstriction of its branches only

Somatic branches (Vasomotor Sudomotor Pilomotor)

Visceral branches

Vascular branches

SYMPATHETICS IN PARASYMPATHETIC GANGLIA

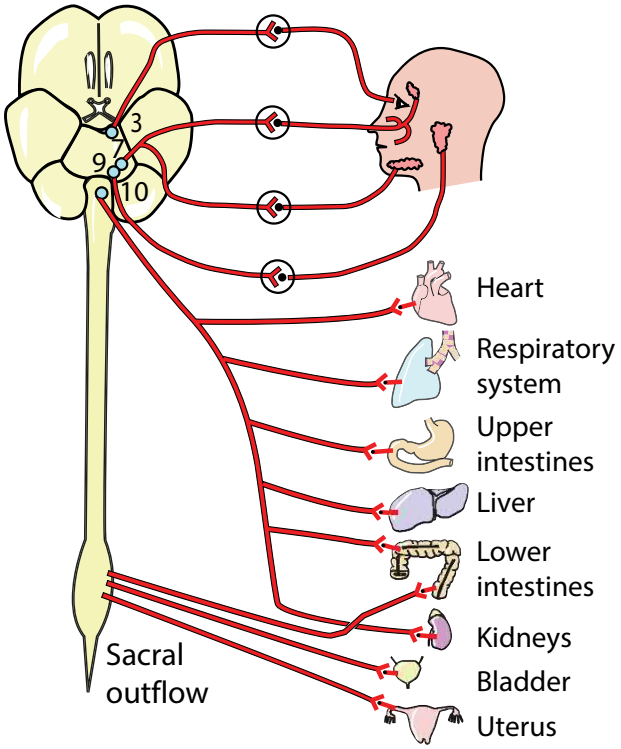


Sympathetics from the superior cervical ganglion are carried on an artery before passing through a parasympathetic ganglion

A typical parasympathetic ganglion

There are always sympathetic fibres passing through each of the parasympathetic ganglia. They arise from the internal carotid for the ciliary and pterygopalatine ganglia and branches of the external carotid for the submandibular and otic ganglia. They do not synapse in these parasympathetic ganglia as they have already synapsed in the superior cervical ganglion. They supply vasoconstriction to the end organs and NEVER have special functions such as pupillary dilatation

AUTONOMIC OUTFLOW



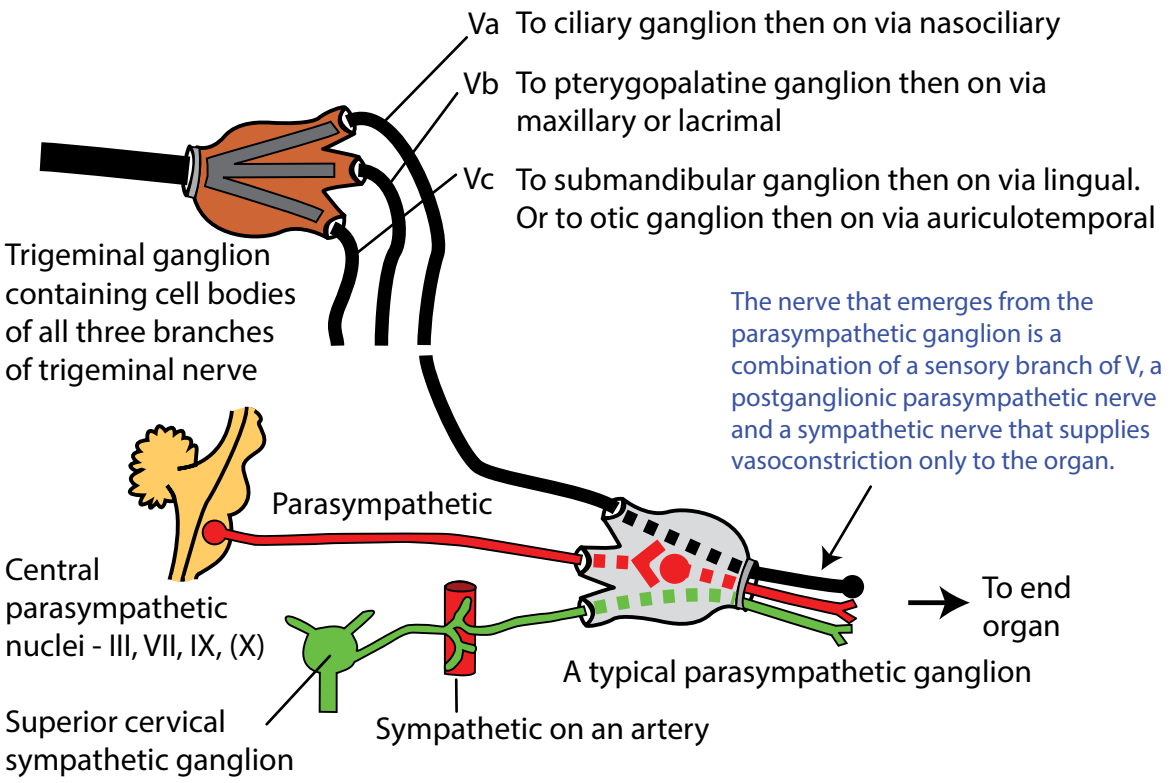
PARASYMPATHETIC

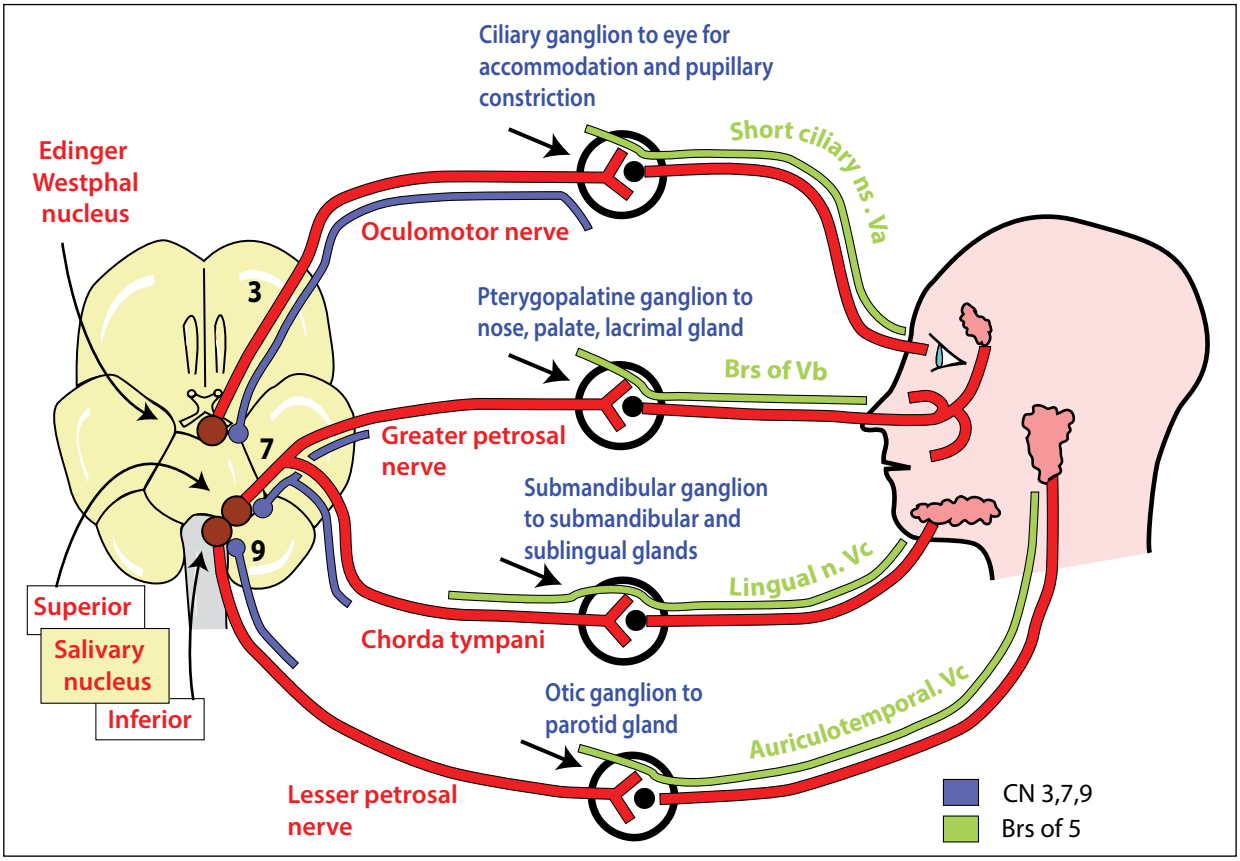
Note that there are 4 specific ganglia in the head but in the rest of the body there are small peripheral ganglia on or near the end-organs.

The vagus reaches to the left side of the transverse colon and then the sacral outflow (S2, 3, 4) takes over.

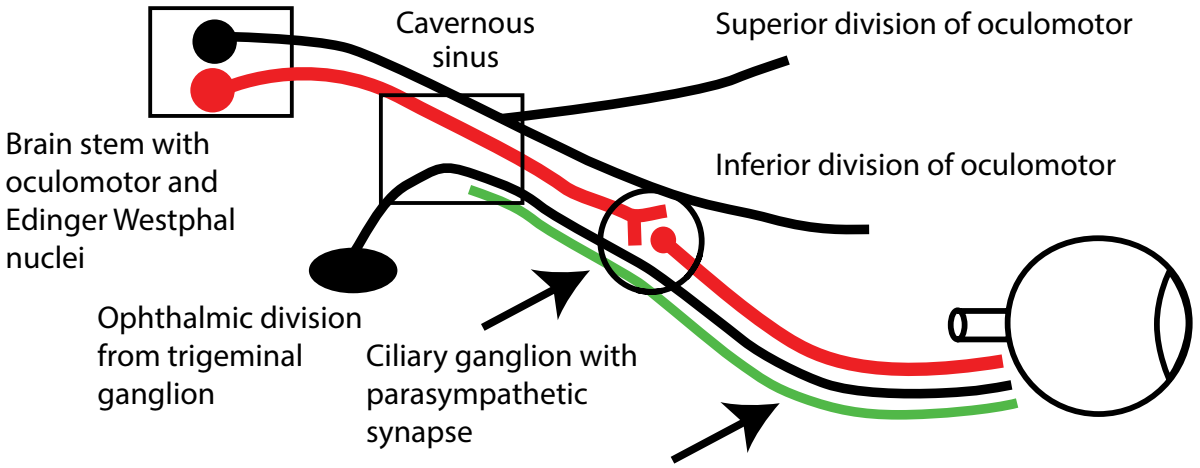
Note : The ratio of pre- to post-ganglionic fibres in a parasympathetic synapse is 1:1

PATTERN OF PARASYMPATHETICS IN HEAD



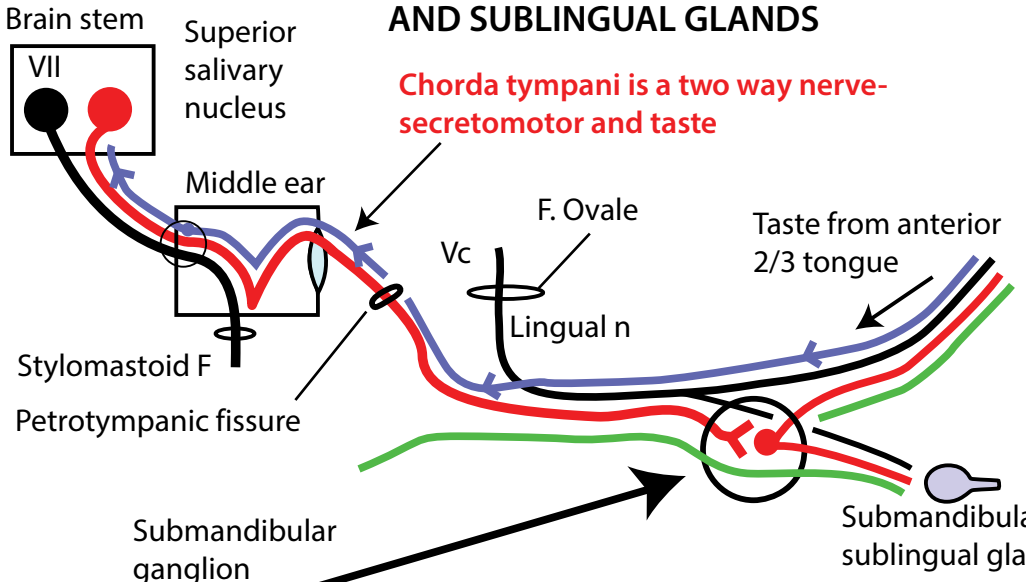


PARASYMPATHETIC PATHWAY FOR PUPILLARY CONSTRICTION AND ACCOMMODATION



Emerging nerve: 10-12 short ciliary nerves with postganglionic parasympathetic, branch of nasociliary (sensory), sympathetic off artery for vasoconstriction.

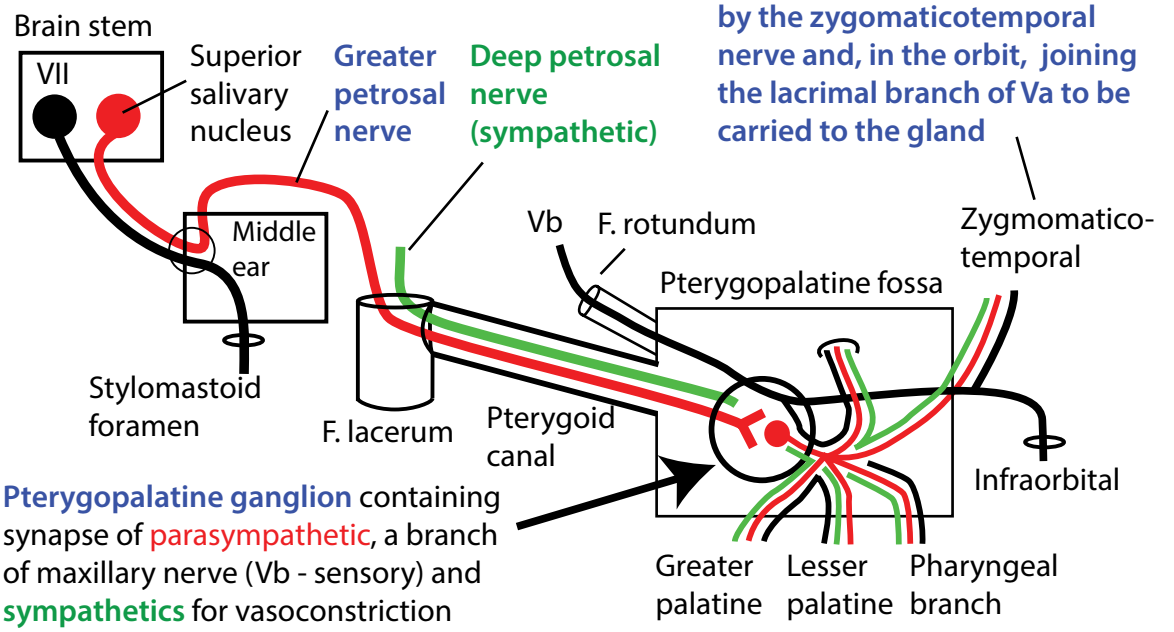
PARASYMPATHETIC PATHWAY TO SUBMANDIBULAR AND SUBLINGUAL GLANDS



Emerging nerves: Postganglionic parasympathetic to submandibular and sublingual glands; branch of lingual nerve (Vc sensory); sympathetic for vasoconstriction; taste returning from tongue in chorda tympani

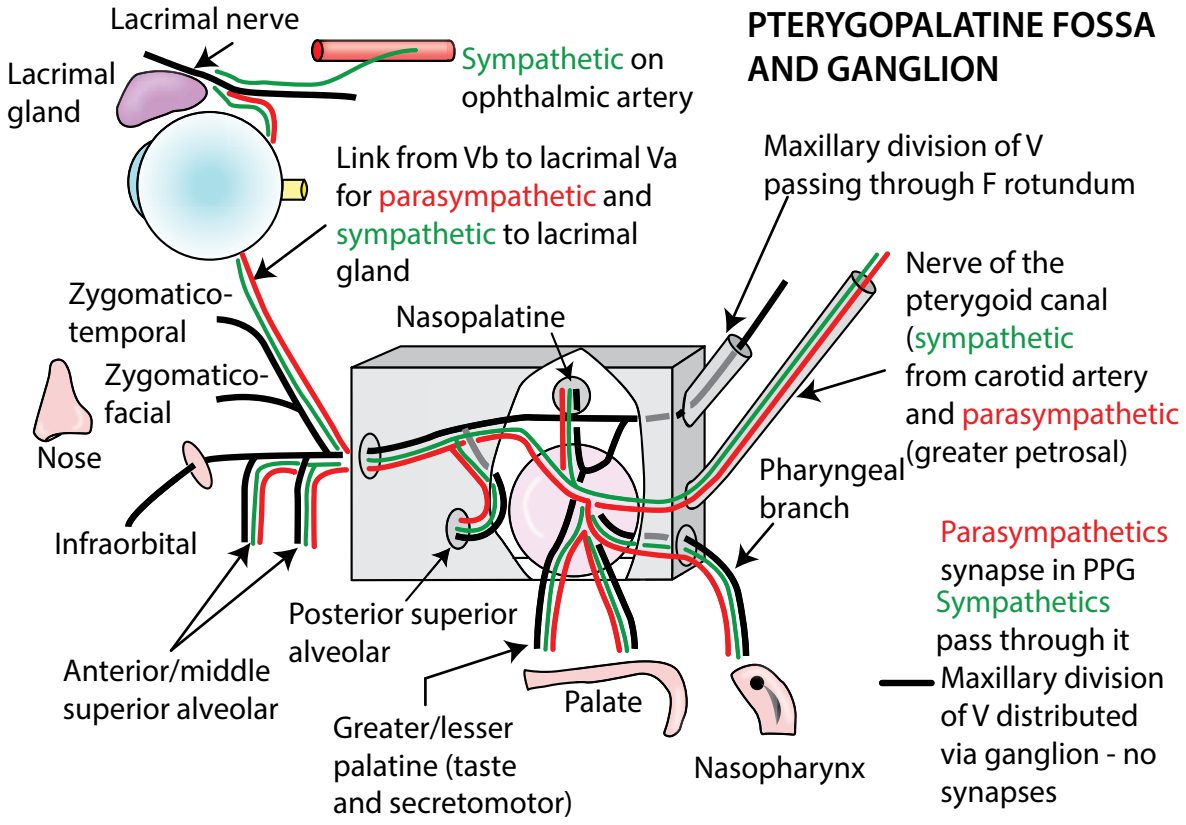
PARASYMPATHETIC PATHWAY TO NOSE, SINUSES, AND LACRIMAL GLAND

Postganglionic parasympathetics reach the lacrimal gland carried by the zygomaticotemporal nerve and, in the orbit, joining the lacrimal branch of Va to be carried to the gland

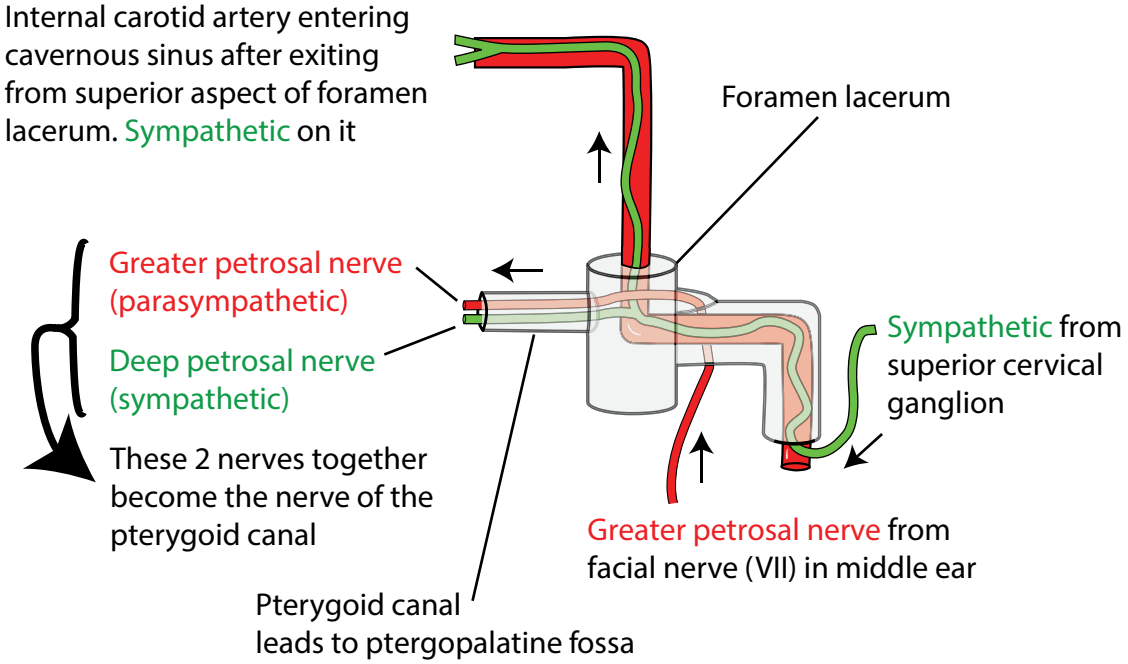


Pterygopalatine ganglion containing synapse of parasympathetic, a branch of maxillary nerve (Vb - sensory) and sympathetics for vasoconstriction

PTERYGOPALATINE FOSSA AND GANGLION

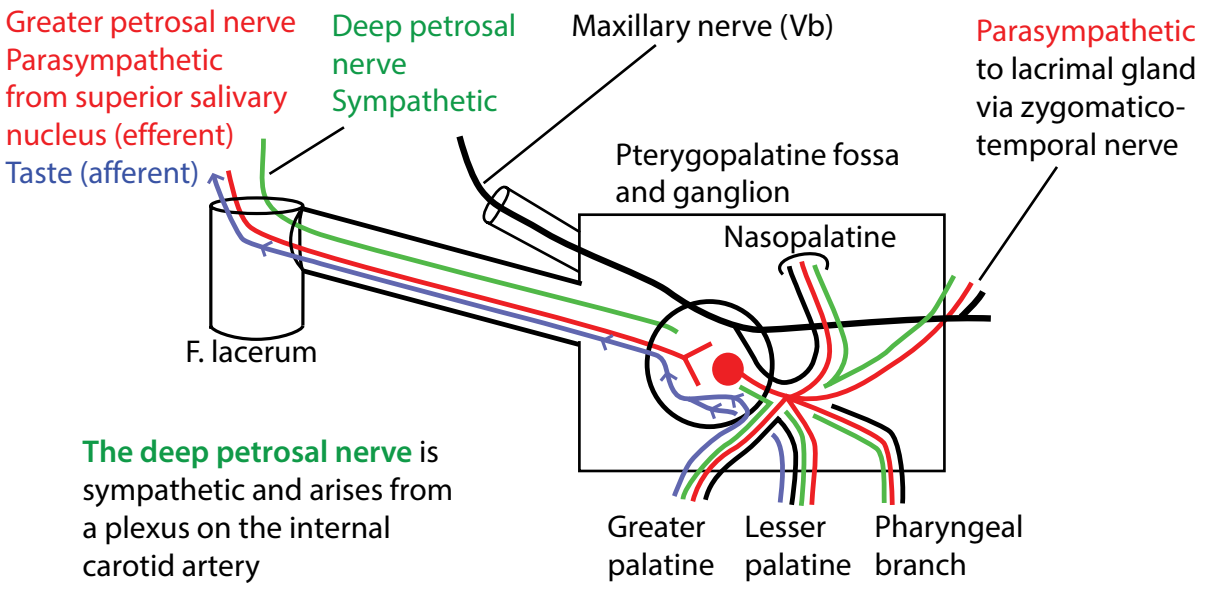


FORAMEN LACERUM



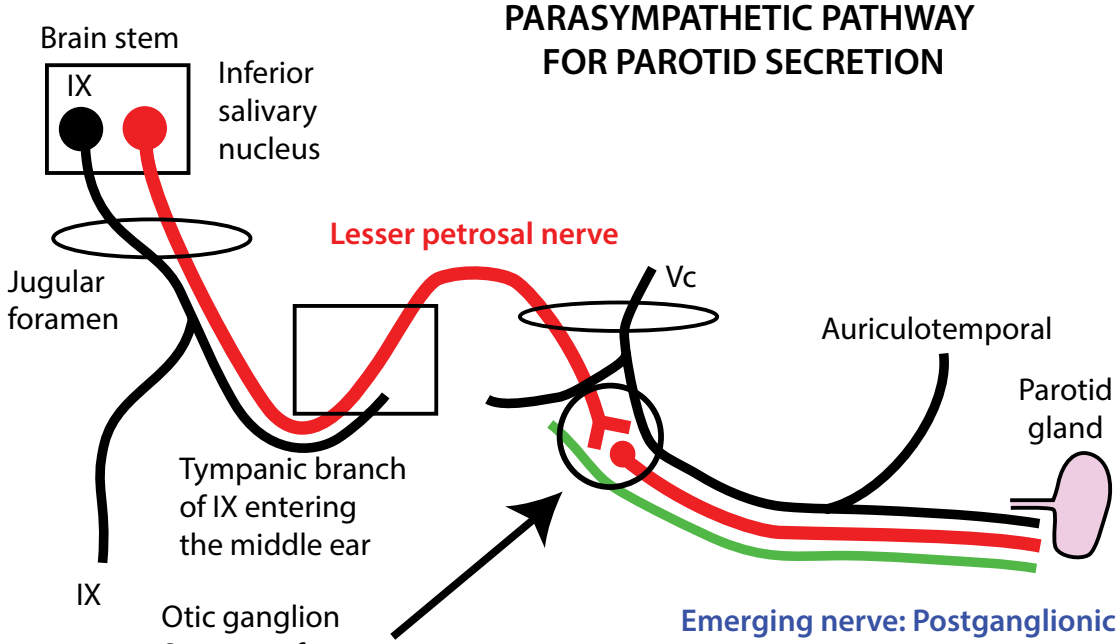
TASTE FROM THE PALATE

Taste returns from the palate in the greater and lesser palatine nerves via the pterygopalatine ganglion (not synapsing) and then to the greater petrosal nerve to reach its cell bodies in the **geniculate ganglion** in the middle ear. Passes centrally to the tractus solitarius



The deep petrosal nerve is sympathetic and arises from a plexus on the internal carotid artery

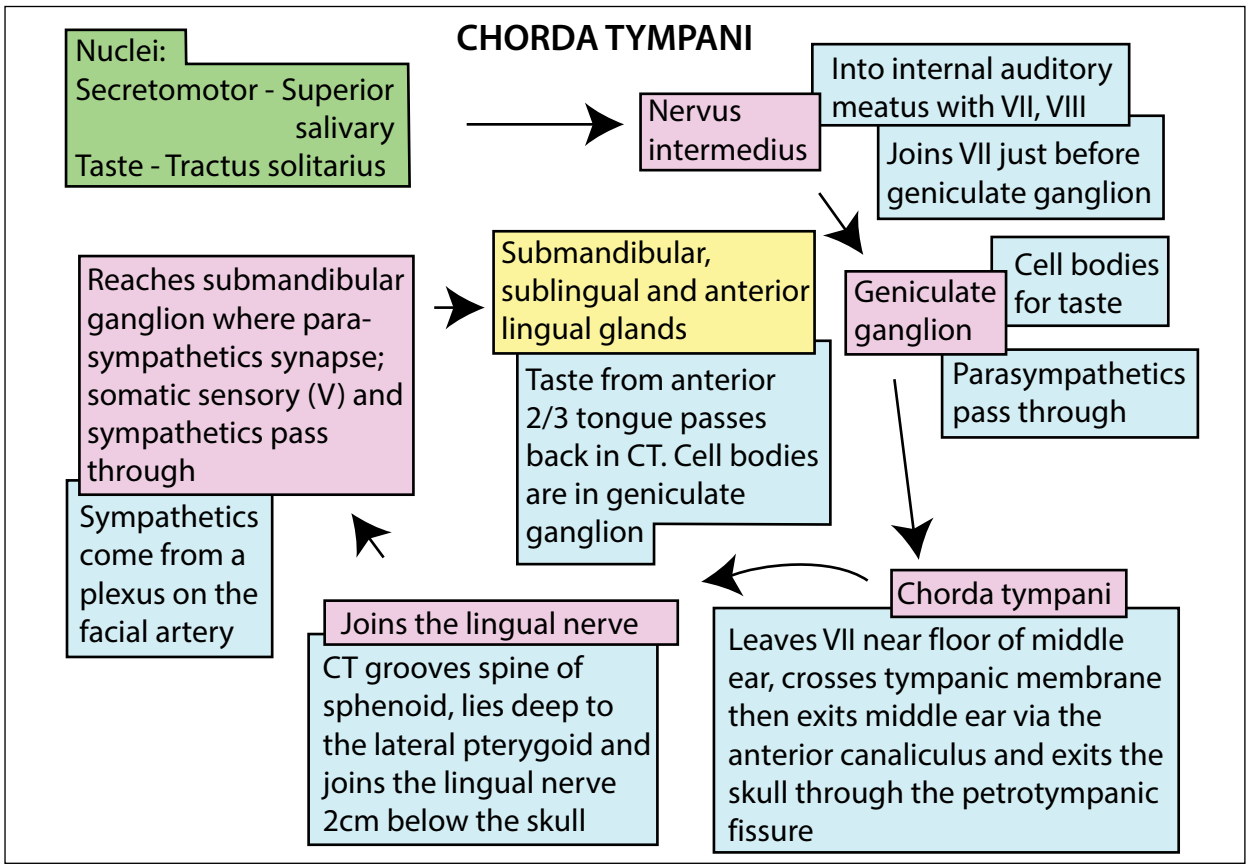
PARASYMPATHETIC PATHWAY FOR PAROTID SECRETION



Emerging nerve: Postganglionic parasympathetic, branch of auriculotemporal (sensory), sympathetic (vasoconstriction)

SUMMARY AND KEY POINTS OF PARASYMPATHETICS

- Parasympathetic output in the body is only carried by cranial nerves oculomotor (III), facial (VII), glossopharyngeal (IX) and vagus (X) and sacral segments S2,3,4.
- In the head it constricts the pupil, accommodates the eye and stimulates the salivary and lacrimal glands secrete. The vagus supplies the viscera as far as the left side of the transverse colon. Below that the supply is from S2,3,4 output.
- Each vagus nerve has two branches in the neck to the heart. There are further vagal branches to the heart and respiratory system in the chest and branches in the abdomen as far as the left transverse colon.
- The parasympathetics from S2,3,4 arise from cell bodies in the lateral horn of the spinal cord but emerge with the somatic motor nerves via the ventral horn. They join the pelvic plexus as the pelvic splanchnic nerves.
- True parasympathetic nerves are all motor. Sensory nerves within the parasympathetic system are general visceral afferent nerves that run with the parasympathetics but are not strictly part of the system.
- The vagus nerves and the output from S2,3,4 are all preganglionic fibres which all synapse in small peripheral ganglia on or near the organs of distribution.
- In the head there are four special parasympathetic ganglia (ciliary, pterygopalatine, submandibular and otic) for synapsing.
- There is no parasympathetic supply to limbs or gonads (ovaries and testes).



GREATER PETROSAL NERVE

Nuclei:
Secretomotor - Superior salivary
Taste - Tractus solitarius

→ Nervus intermedius

Into internal auditory meatus with VII, VIII

Joins VII just before geniculate ganglion

Geniculate ganglion

Cell bodies for taste

Parasympathetics leave facial nerve (VII) and pass out of ganglion

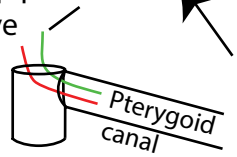
Greater Petrosal nerve

Through roof of petrous temporal, into middle cranial fossa between layers of dura, under trigeminal ganglion to reach foramen lacerum

Enters pterygoid canal at upper, anterior end of foramen lacerum as nerve of pterygoid canal

Joined by deep petrosal nerve (sympathetic from plexus on internal carotid artery)

Deep petrosal nerve



Foramen lacerum

Distributes to nose, sinuses, palate,naso-pharynx and lacrimal gland

Taste returns from palate

Enters pterygopalatine (hayfever) ganglion in its fossa where parasympathetics synapse; somatic sensory (V) and sympathetics pass through

LESSER PETROSAL NERVE

Nucleus:
Secretomotor - Inferior salivary

→ Tympanic branch of glossopharyngeal (IX) nerve

Leaves IX just below its ganglion

Enters the middle ear onto the promontory where it mixes with parasympathetic from facial (VII) and sympathetic

Lesser petrosal nerve

Leaves middle ear high up on anteromedial wall

Into middle cranial fossa

Gets there through roof of petrous temporal and lies between layers of dura

Leave skull through foramen ovale

Otic ganglion

Parasympathetics now synapse. Sympathetics are picked up from the middle meningeal artery and passes through ganglion together with somatic sensory nerves (Vc - auriculotemporal nerve)

Parotid gland

Parasympathetics and sympathetics travel on the auriculotemporal nerve (somatic sensory - Vc) and are dropped off at the parotid gland as the nerve passes by

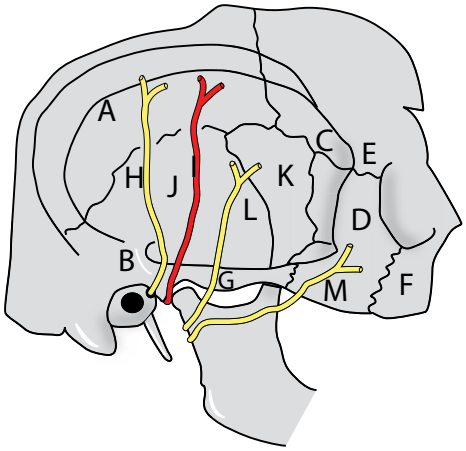
PARASYMPATHETIC PATHWAYS

Cranial nerve	Central nucleus	Nerve carrying preganglionic fibres	Pathway and foramen	Site of ganglion	Name of ganglion	Nerve carrying postganglionic fibres	Organ supplied
3	Edinger-Westphal (mid brain)	III via nerve to inferior oblique	Cavernous sinus to SOF to orbit	Between optic n and lateral rectus in apex of orbit	Ciliary	Nasociliary and short ciliary (Va)	Ciliary muscle for accommodation. Circular muscle for pupil constriction
7	Superior salivary (pons)	VII (NI) then greater petrosal	IAM to middle ear to MCF to pterygoid canal	Pterygopalatine fossa	Pterygo-palatine	Maxillary brs (Vb) Zygomatico-temporal to lacrimal (Va)	Mucous glands in nose, naso-pharynx soft palate Lacrimal gland
7	Superior salivary (pons)	VII (NI) then CT to lingual nerve	IAM to middle ear to petrotympanic fissure to ITF	Below lingual nerve on hyoglossus	Sub-mandibular	Lingual (Vc)	Sublingual and Submandibular salivary glands
9	Inferior salivary (medulla)	IX to tympanic branches to lesser petrosal	Middle ear to MCF to f ovale	Below formen ovale on nerve to tensor tympani/palati	Otic	Auriculo-temporal (Vc)	Parotid salivary gland
9		Pharyngeal and laryngeal branches	Direct to oropharynx and post 1/3 tongue	In relevant mucosa			Mucous glands oropharynx and post 1/3 tongue
10	Dorsal motor (medulla)	X (vagus)	Cardiac branches in neck. Thorax and abdomen	On target organs			Viscera of thorax and abdomen down to transverse colon

SOF = Superior orbital fissure
NI = Nervus intermedius
IAM = Internal auditory meatus
IF = Infratemporal fossa
CT = Chorda tympani
MCF = Middle cranial fossa

5.19 Temporal, Infratemporal and Pterygopalatine Fossae

RIGHT TEMPORAL FOSSA

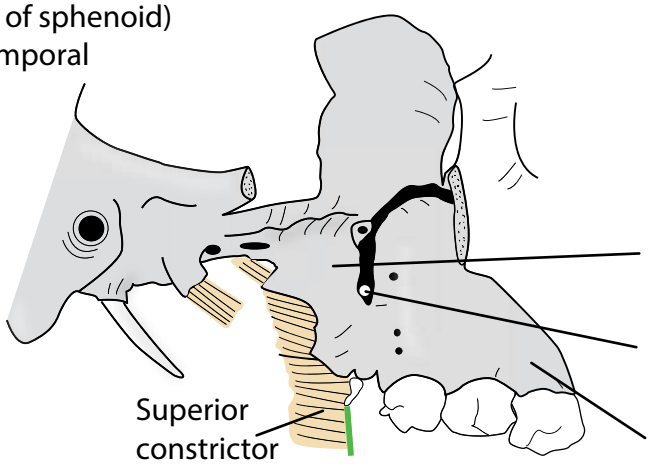


Medial to temporalis which is attached to, and below inferior temporal line (A)
Roof: Temporalis fascia
Posterior: Supramastoid crest (B)
Floor: Skull - pterion (C)
Anterior: Zygoma (D), zygomatic process of frontal bone (E) and zygomatic process of maxilla (F)
Inferior: Zygomatic arch and zygomatic process of temporal bone (G)

Contains: Temporalis, deep temporal arteries (maxillary), deep temporal nerves (Vc), Superficial temporal artery (external carotid). Auriculotemporal nerve (H) from mandibular nerve (Vc)
Other structures shown: Temporal bone (J), greater wing of sphenoid (K), Temporal branch of facial (VII) (L), zygomatic branch of facial (VII) (M)

INFRATEMPORAL FOSSA - BOUNDARIES

ROOF
- Infratemporal crest (greater wing of sphenoid)
- Squamous temporal



MEDIAL WALL
- Tensor palati
- Levator palati
- Superior constrictor
- Lateral pterygoid plate
- Pterygomaxillary fissure
- Maxilla

- **POSTERIOR WALL**
  Carotid sheath

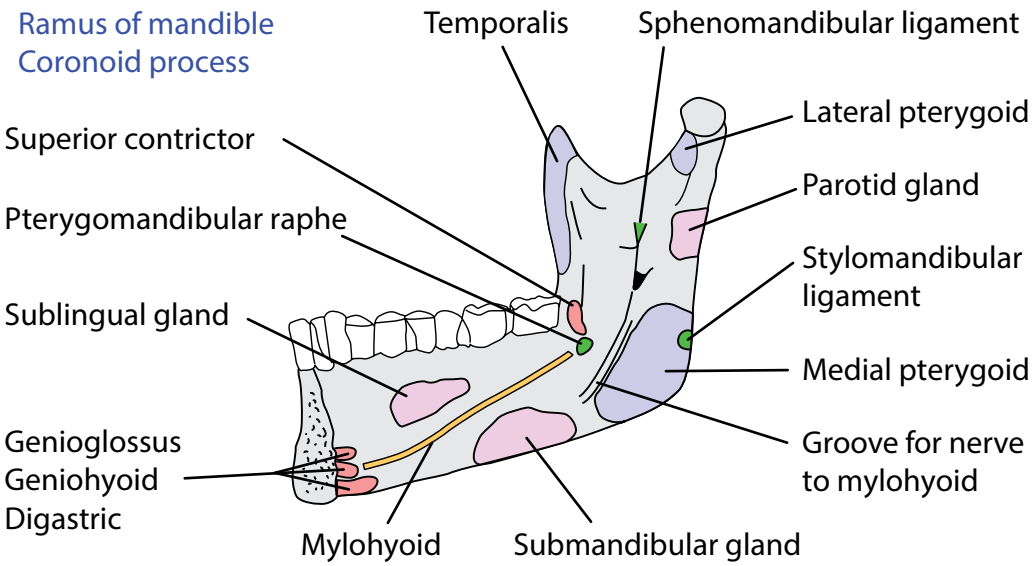
ANTERIOR WALL
- Posterior maxilla
- Inferior orbital fissure

INFRATEMPORAL FOSSA - BOUNDARIES

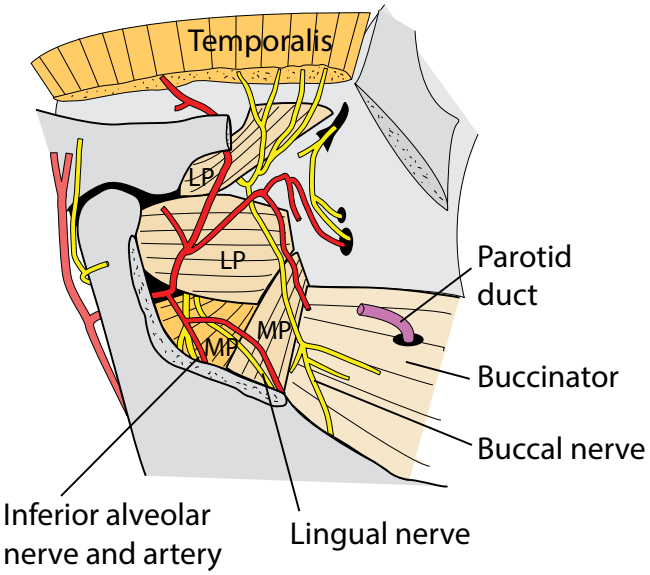
- Base of skull
- Between pharynx and ramus of mandible

LATERAL WALL

Ramus of mandible
Coronoid process



INFRATEMPORAL FOSSA

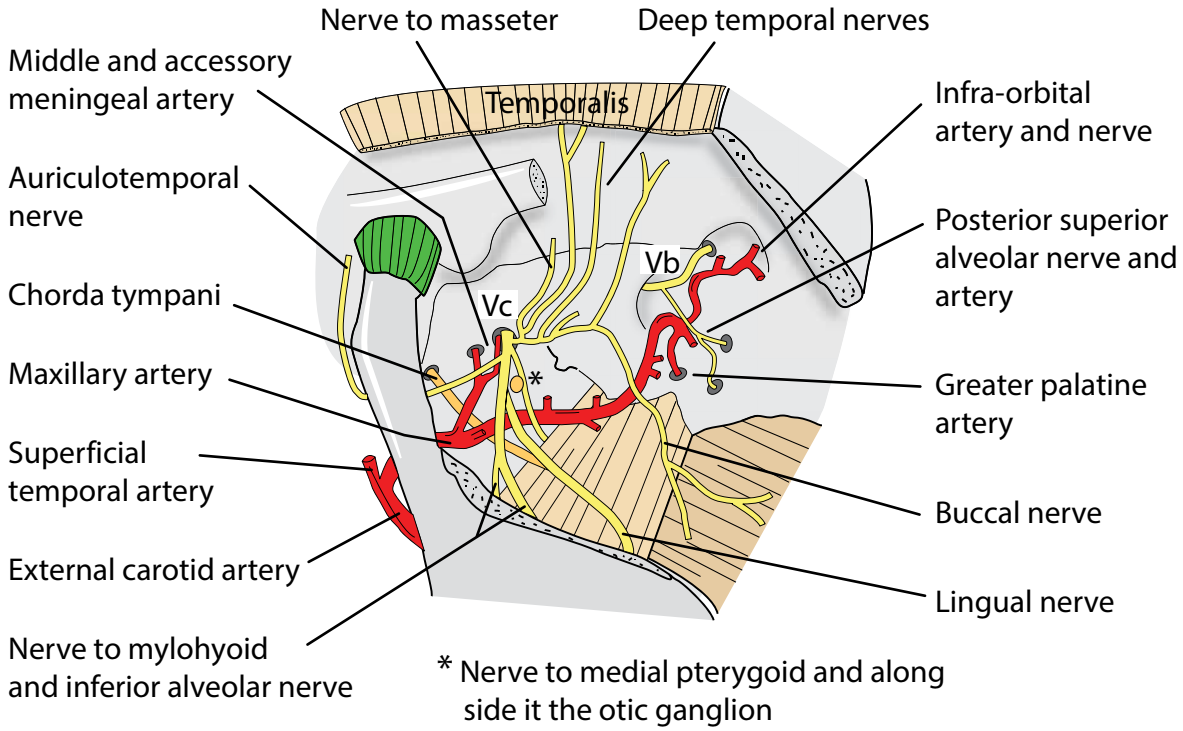


CONTENTS

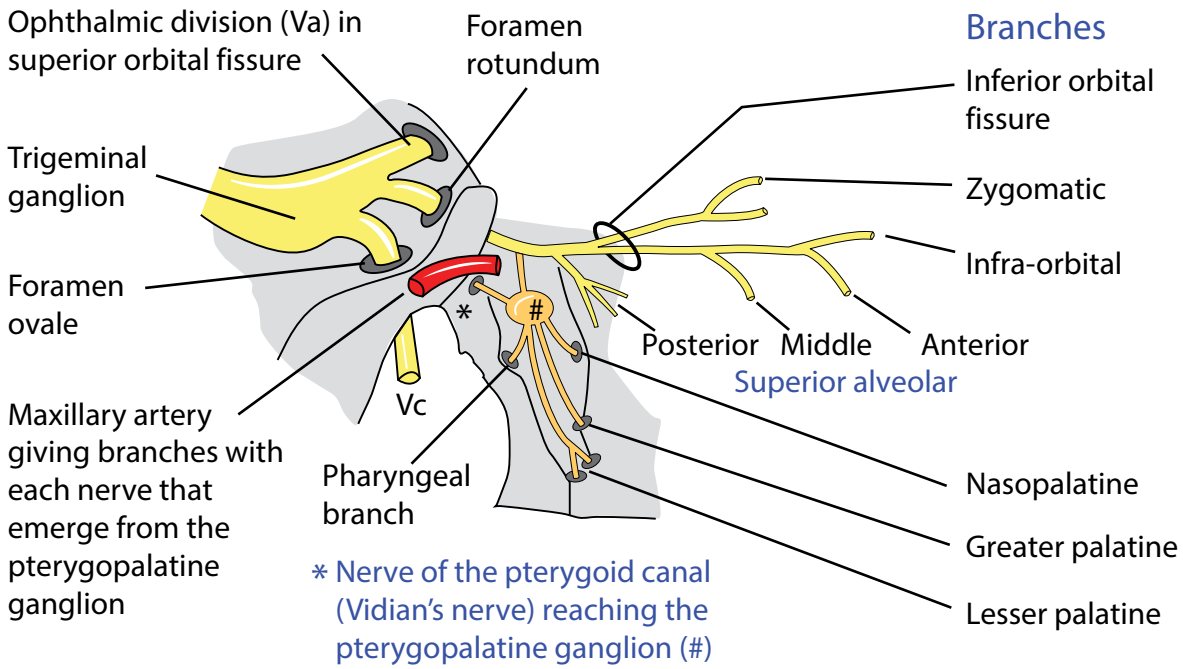
- Pterygoid muscles
- Pterygoid venous plexus
- Fat
- Mandibular nerve and branches
- Insertion of temporalis
- Otic ganglion
- Chorda tympani
- Maxillary artery and branches
- Posterior superior alveolar branches of maxillary nerve (Vb)

LP = lateral pterygoid
MP = medial pterygoid

INFRATEMPORAL FOSSA - DEEP DISSECTION



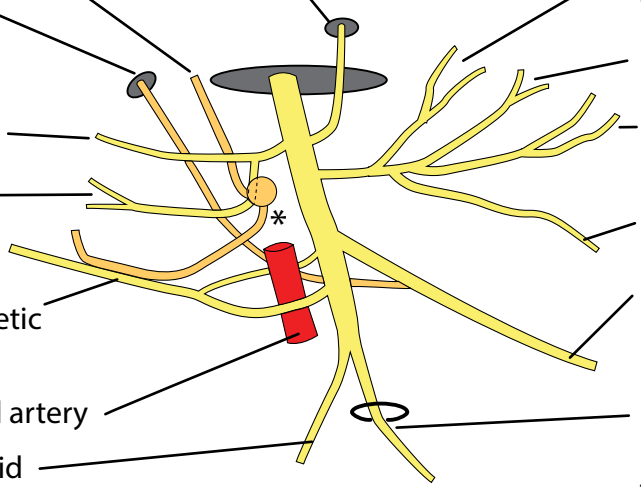
MAXILLARY DIVISION OF TRIGEMINAL NERVE IN PTERYGOPALATINE FOSSA



Parasympathetic to nose, sinuses, palate, nasopharynx and lacrimal gland
Maxillary nerve (Vb) to upper teeth, floor of orbit, face/skin

MANDIBULAR DIVISION OF TRIGEMINAL NERVE (Vc)

Foramen ovale to infratemporal fossa

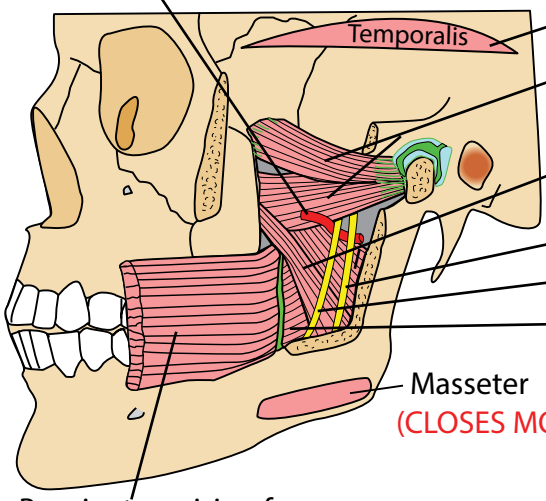


Branches

- Anterior and posterior deep temporal
- Masseteric
- Lateral pterygoid
- Buccal
- Lingual (joined by chorda tympani)
- Inferior alveolar (inferior alveolar foramen)

* **Otic ganglion:** Parasympathetics from lesser petrosal nerve synapse within it and postganglionic fibres are taken to parotid gland by auriculotemporal nerve (Vc)

MUSCLES OF MASTICATION



- Temporalis (CLOSES MOUTH)
- Upper and lower heads of lateral pterygoid (OPEN MOUTH)
- Deep and superficial heads of medial pterygoid (CLOSE MOUTH)
- Inferior alveolar nerve
- Lingual nerve
- Superior constrictor arising from pterygomandibular raphé

Pterygoid muscles contain venous plexuses that connect with veins both inside (cavernous sinus) and outside the skull (facial veins)

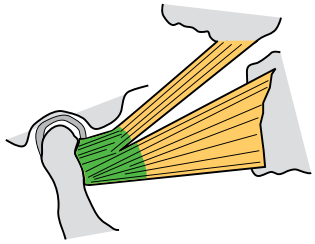
QUICK RULES FOR IDENTIFYING STRUCTURES IN INFRATEMPORAL FOSSA

1. Any muscle lying horizontally is lateral pterygoid.
2. Any muscle lying vertically is medial pterygoid.
3. Any large artery is the maxillary.
4. Two large nerves: Posterior one into mandible is inferior alveolar. Anterior one is lingual.
5. A muscle lying anteriorly and perforated by parotid duc

MUSCLES OF MASTICATION

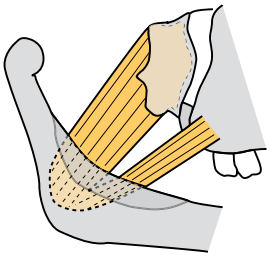
- Temporalis
- Masseter
- Medial pterygoid
- Lateral pterygoid

All supplied by:
- Mandibular division of Trigeminal (Vc)
- All derived from 1st pharyngeal arch



LATERAL PTERYGOID

Arises: 2 heads:
Upper - infratemporal surface sphenoid
Lower - lateral surface of lateral pterygoid plate
Inserts: pterygoid fossa below head of mandible, disc and capsule of temporomandibular joint
Action: protrudes jaw and opens mouth

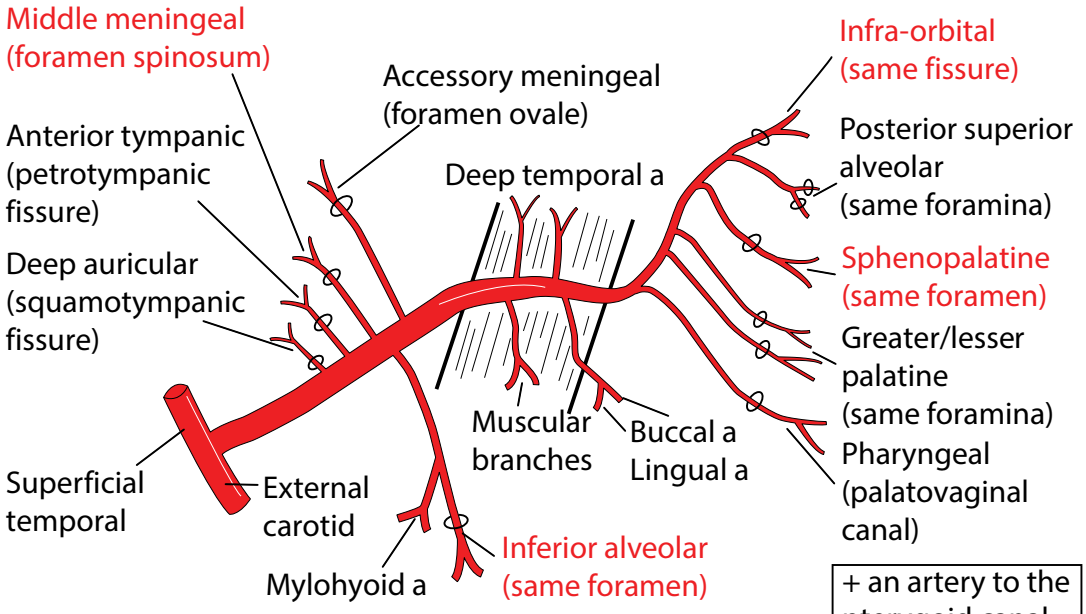


MEDIAL PTERYGOID

Arises: 2 heads:
Deep - medial side of lateral pterygoid plate and fossa between plates
Superficial - smaller. Tuberosity of maxilla and pyramidal process of palatine bone
Inserts: Medial ramus of mandible
Action: pulls mandible upwards, forwards and medially (closes mouth and chews)

MAXILLARY ARTERY

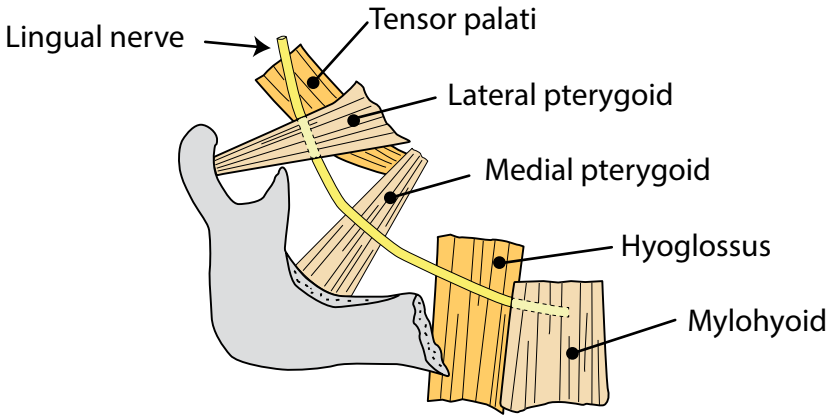
In infratemporal fossa, within or lateral to superficial head of lateral pterygoid muscle (shown below)



+ an artery to the pterygoid canal

Before lateral pterygoid 5 branches into bone.
Lateral or within lateral pterygoid. 4/5 branches to soft tissue.
Beyond lateral pterygoid 5/6 branches with nerves.

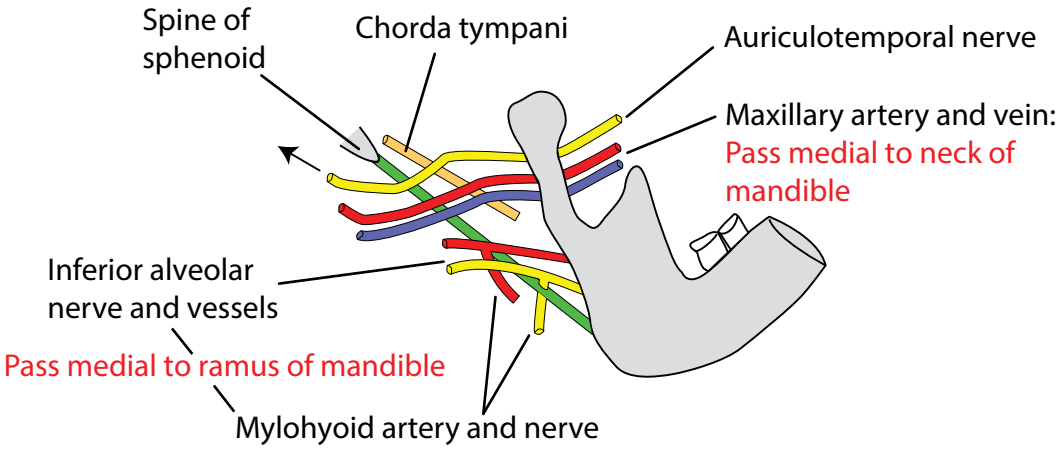
LINGUAL NERVE: RELATION TO MUSCLES



The lingual nerve can be considered as a "2-way nerve":
SENSORY: General sensory: Anterior 2/3 tongue
Taste (via chorda tympani): Anterior 2/3 tongue
MOTOR: Secretomotor (via chorda tympani): Submandibular and sublingual glands

SPHENOMANDIBULAR LIGAMENT RELATIONS

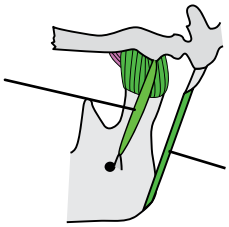
Structures that pass between sphenomandiblular ligament and mandible



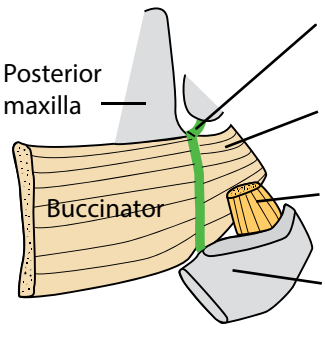
Note that nerve to mylohyoid often pierces the ligament

LIGAMENTS ASSOCIATED WITH MANDIBLE AND HYOID

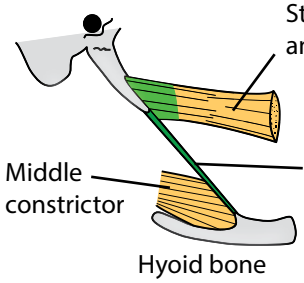
SPHENOMANDIBULAR LIGAMENT
Spine of sphenoid to lingula of mandible (1st arch remnant). Is the axis of rotation for opening of mouth



STYLOMANDIBULAR LIGAMENT
Specialised band of deep cervical fascia. Styloid process to angle of mandible. Is the postero-inferior aspect of the parotid fascia



PTERYGOMANDIBULAR RAPHÉ
Tendinous muscle fibres from pterygoid hamulus to posterior end of mylohyoid line. Medially: Buccal mucosa. From it: Superior constrictor posteriorly and buccinator anteriorly. Buccinator also extends onto pterygo-maxillary ligament to reach maxilla

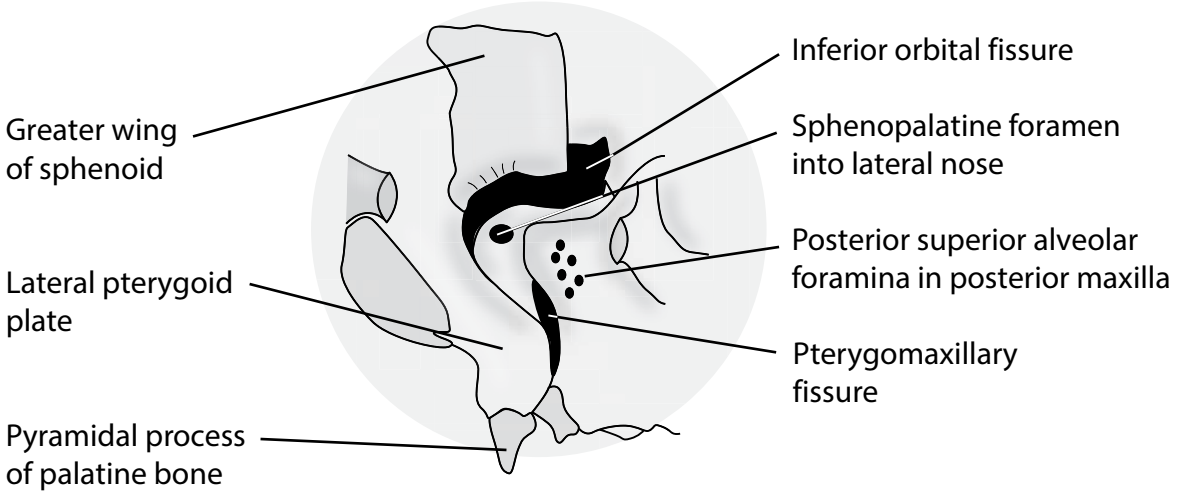


STYLOHYOID LIGAMENT
Tip of styloid process to lesser cornu of hyoid. 2nd arch remnant. Styloglossus from its upper end and middle constrictor from its lower end

RIGHT PTERYGOPALATINE FOSSA

Looking in from the lateral side

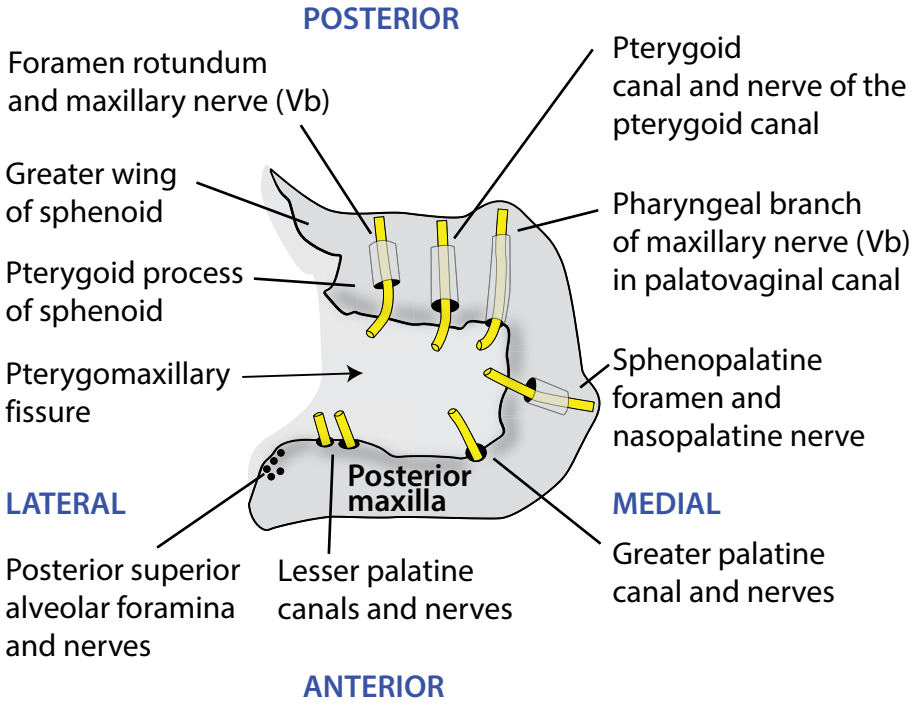
POSTERIOR **ANTERIOR**



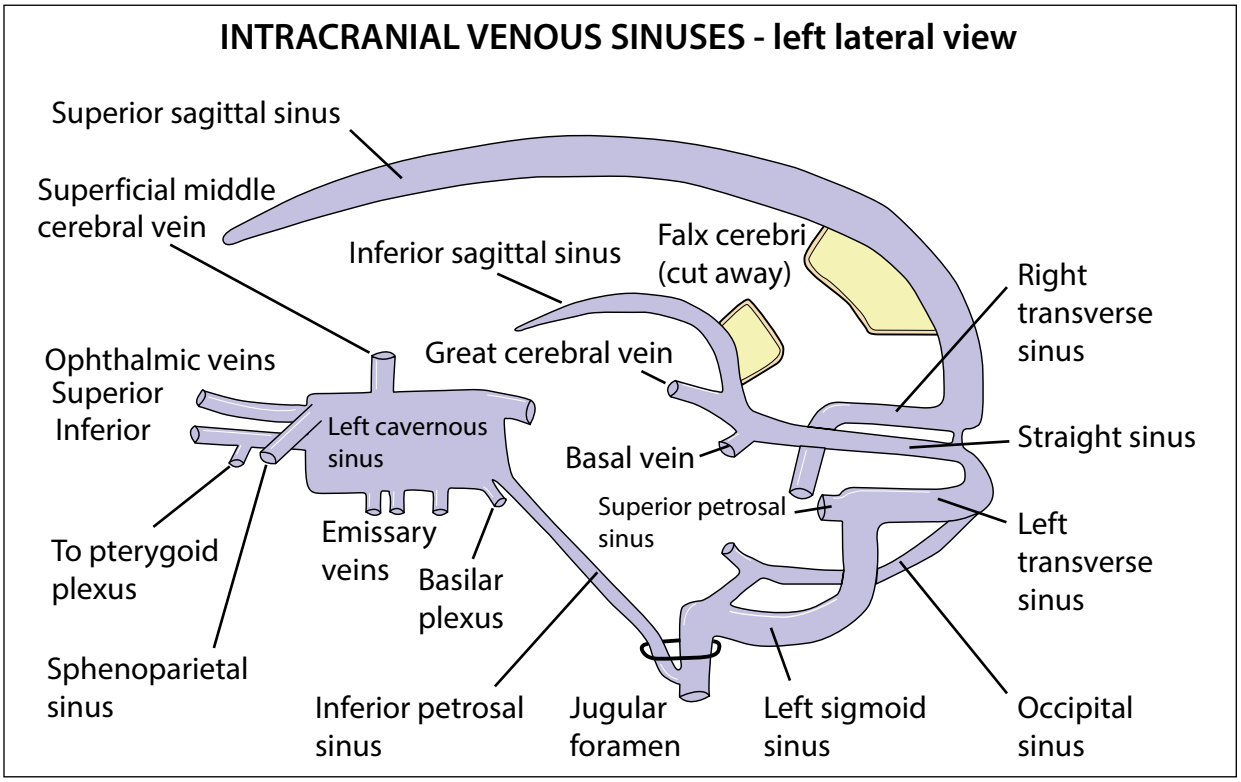
Lateral access into the fossa is via the pterygomaxillary fissure. Other entry and exit sites are shown on a separate illustration

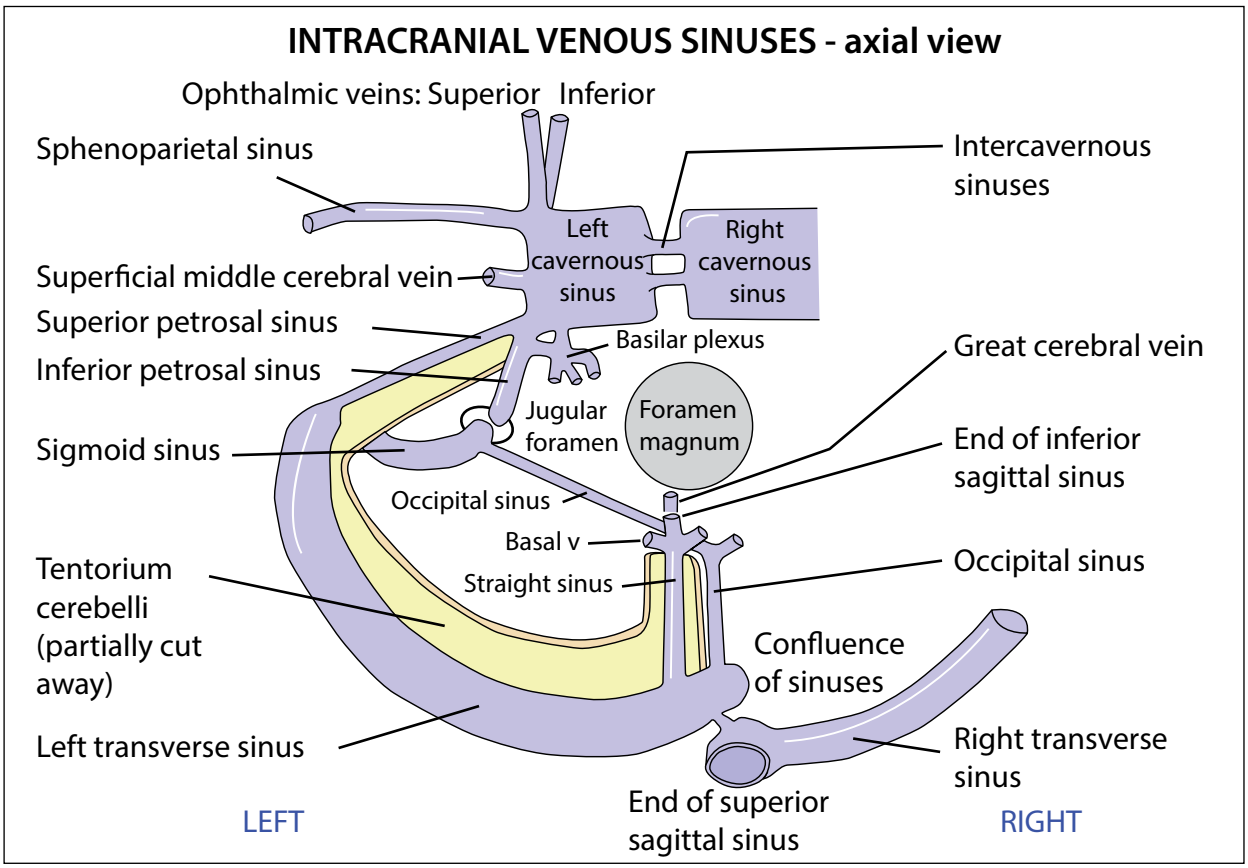
PTERYGOPALATINE FOSSA - VIEWED FROM ABOVE

Diagrammatic view of right fossa looking down on it from above to show entry and exit of nerves. The roof (removed) is greater wing of sphenoid

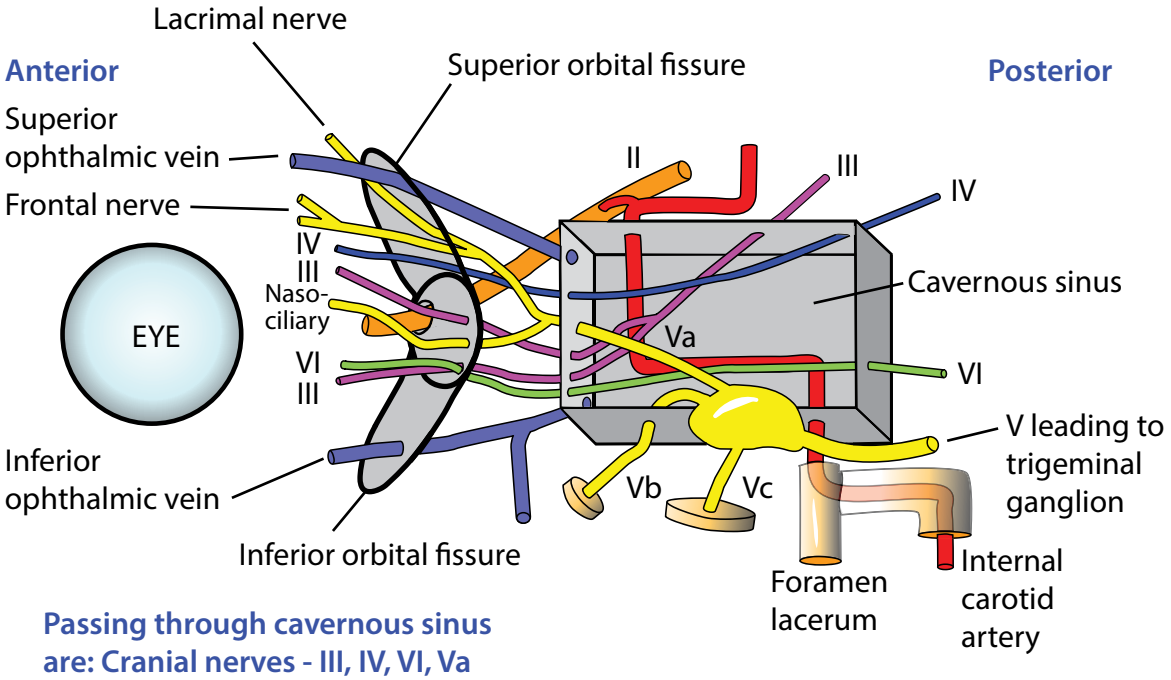


5.20 Cavernous Sinus and other Venous Sinuses





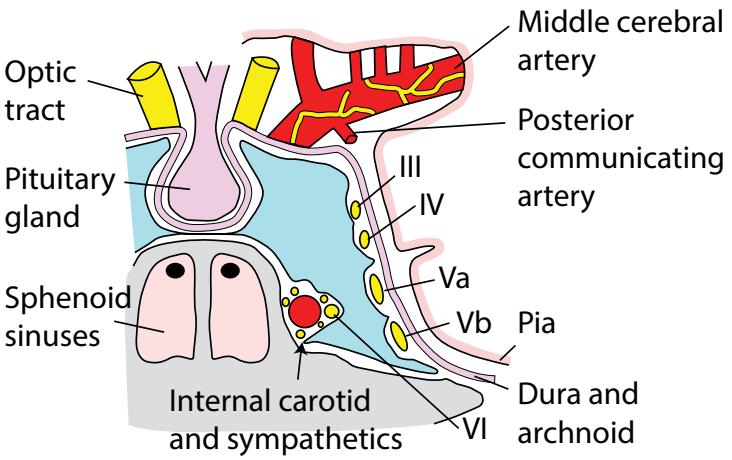
LEFT CAVERNOUS SINUS



Passing through cavernous sinus are: Cranial nerves - III, IV, VI, Va and Vb (briefly). Internal carotid artery carrying sympathetics

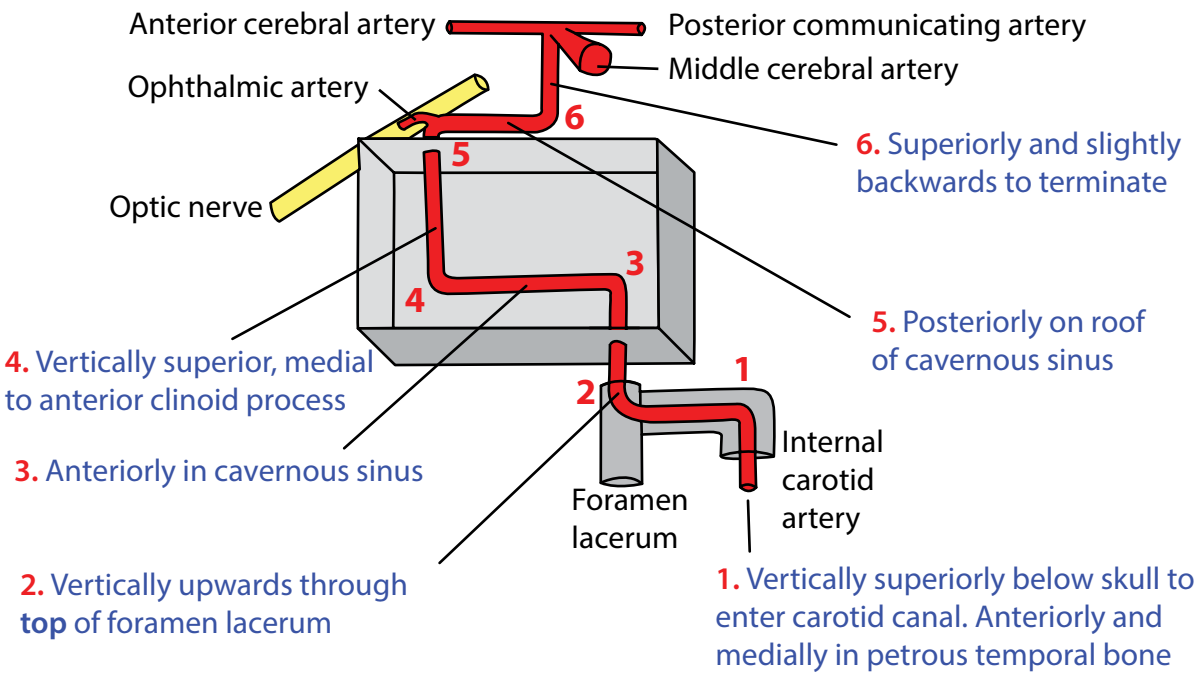
CAVERNOUS SINUS - CORONAL (TRANSVERSE) VIEW RIGHT SIDE LOOKING ANTERIORLY

In: Middle cranial fossa. **Alongside:** Body of the sphenoid. **Between:** Endosteal and meningeal dura. **Roof:** Anterior and posterior clinoid processes with uncus of temporal lobe and internal carotid artery on it, III and IV into it. **Lateral wall:** Dura, temporal lobe, III, IV, Va, Vb in wall. **Floor:** Greater wing of sphenoid. **Medial wall:** Dura over sphenoid, sella turcica, pituitary, sphenoid sinus.



Posterior wall: Dura of posterior fossa, superior and inferior petrosal sinuses, peduncle of brain. **Anterior wall:** Medial end of superior orbital fissure, ophthalmic veins, orbit. **Contains:** Internal carotid artery, VI and blood. **Draining into it:** Superior and inferior ophthalmic veins, intercavernous sinuses, sphenoparietal sinuses, superficial middle cerebral vein. **Draining out of it:** Superior and inferior petrosal sinuses, emissary veins to pterygoid plexus

6 RIGHT ANGLE BENDS OF THE INTERNAL CAROTID ARTERY



6. Superiorly and slightly backwards to terminate

5. Posteriorly on roof of cavernous sinus

4. Vertically superior, medial to anterior clinoid process

3. Anteriorly in cavernous sinus

2. Vertically upwards through **top** of foramen lacerum

1. Vertically superiorly below skull to enter carotid canal. Anteriorly and medially in petrous temporal bone

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